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ORIGINAL ARTICLES.

I.—Notes on British Dinosaurs. Part III: *Streptospondylus*.

By Dr. Francis Baron Nopcsa.

(PLATE XV.)

AFTER having studied a bipedal and a quadrupedal Orthopodous Dinosaur I thought it desirable to turn my attention to a bipedal representative of the Saurischian order.[1]

Though *Streptospondylus* is by no means an exclusively British Dinosaur, since the type-specimen is preserved in the Jardin des Plantes in Paris, and was described under the names *Streptospondylus* and *Megalosaurus* by Cuvier and Gaudry, still, the only other specimen known, and by far the best, is in Mr. J. Parker's private collection at Oxford. It is to Mr. Parker's kindness that I owe the possibility of studying and drawing what may be called one of the most complete Theropods ever found, while in the Paris Collection *Streptospondylus* is only represented by several vertebræ, a fragment of the femur, and the distal part of the tibia with the corresponding astragalus. Mr. Parker's specimen includes the skull, most of the cervical, dorsal, sacral, and some of the caudal vertebræ, the scapulo-coracoid, parts of both humeri, the ilium, ischium, parts of the pubis, both femora, tibiæ, and fibulæ, some tarsal and all the metatarsal bones, and several phalanges.

[1] The quite exceptional economic *rôle* of Dinosaurs during the greater part of the Mesozoic era justifies, I believe, the quite exceptional term 'subclass Dinosauria.' The term Opisthocœlia, as recently and persistently used by some American authors, is decidedly a misnomer, for besides being absolutely misleading—since opisthocœlian vertebræ occur among Sauropoda, Theropoda, and Orthopoda—it was originally not even used for a defined group of Dinosaurs, but for what might be called a *potpourri* of Dinosaurian and Crocodilian reptiles. If one wants to emphasize the fact that Theropoda and Sauropoda form a unit in consequence of their showing greater affinities to each other than to the Orthopoda, cf. Hulke's paper on *Dystrophæus* the term Saurischia, as clearly defined by Professor Seeley, is applicable to these reptiles. I desire to protest most energetically against the use of the term 'Opisthocœlia.'

Since a detailed description of *Streptospondylus* is far beyond the scope of this paper, I intend to publish such a description in the *Beiträge zu Geologie und Palaeontologie* (Vienna), and here, in accordance with my previous Notes on British Dinosaurs, only the most salient points will be mentioned. First of all, it has to be remarked that Mr. Parker's fossil indicates a much smaller and, as the structure of the sacrum shows, a more immature individual than that in the Paris Museum.

The *skull*, which is altogether missing in the Paris specimen, is nearly complete in the Oxford individual, but in consequence of being imperfectly freed from the matrix I could only identify maxillary, præmaxillary, dentary, basis cranii, and quadratum. The greatest possible disproportion is to be remarked between the facial and the cerebral region. The huge jaws are built after the *Megalosaurus* pattern, and the same is also true with regard to the long, compressed, trenchant, and serrated teeth. There exist two, perhaps even three, anteorbital apertures, as in *Creosaurus* and *Megalosaurus*, while in *Ceratosaurus* there is only one. The quadratum is relatively short and points to the existence of a *Creosaurus*-like quadrato-squamosal arch. The short basis cranii shows a strong transverse expansion of the brain in the region of the vagus nerve. The brain-cavity was a good deal larger than the neural canal in the saeral region, and its large size[1] is easily explained by the comparatively high intelligence that *Streptospondylus* must have possessed as an agile carnivorous reptile. Tubera basi-occipitalia seem to be wanting. The diameter of the ball-like occipital condyle cannot have exceeded 2·5 cm.

Vertebræ. The foremost cervical vertebræ are remarkable for their small size, the centra being only 4 cm. long and 2·5 cm. high, while the posterior cervicals attain 6·0 and 3·5 cm., and some dorsals even 8 and 4·5 cm. The neural spines are but feebly developed; the arch shows, much like the primitive Sauropoda, a complex system of diapophysial, oblique, præzygapophysial, postzygapophysial, and horizontal laminæ, and differs in consequence from all the other known Theropods. The centra of the cervical vertebræ are unlike those of *Ceratosaurus*, *Creosaurus*, and the Triassic Theropods, strongly convex in front, deeply concave behind, and show large pleurocentral fossæ.

In the dorsal vertebræ the antero-posteriorly blade-like neural spines are better developed than in the cervicals, the arch is again supported by different laminæ, and the centra pass from a convexo-concave to a plano-concave and further on to a nearly biconcave stage. As we pass backward along the dorsal region the pleurocentral cavities become gradually less pronounced, so that in the posterior dorsals they are altogether wanting. The centra of the sacral vertebræ, though united in the Paris specimen, are free in the *Streptospondylus* in Mr. Parker's collection and show here saddle-shaped intersacral articulations.

[1] I am fully aware this expression seems a euphemism when one thinks of modern reptiles, but it is not so when one thinks of such vegetable-feeders as *Stegosaurus* or *Triceratops*.

The number of the sacral vertebræ seems in *Streptospondylus* to have been augmenting during lifetime from 3 to 4, perhaps even to 5 or more.[1] In general the sacrum shows a great resemblance to that of *Megalosaurus*, whereas in consequence of the development of different laminæ in the dorsal vertebræ—a feature absent in *Megalosaurus*—these parts as well as the cervical region are totally different in these two reptiles.

The biconcave and hourglass-shaped, transversely cylindrical caudal vertebræ in *Streptospondylus* are likewise different from the similarly biconcave and constricted but transversely wedge-shaped caudals of *Poikilopleuron*.[2] As in the caudals of most Dinosaurs, the posterior facet for the chevron bone is much more marked than the anterior, which in this case is nearly altogether wanting.

The rod-like chevrons are both distally and proximally united; they are less compressed and comparatively shorter than in *Iguanodon*, and they are supposed not to have extended so far backwards.

Scapulo-coracoids. Even in the immature Oxford specimen the scapula and the coracoid are firmly united. The blade-like scapula is somewhat concave on the inner side and in consequence somewhat convex on the outer, and is much more slender than in *Megalosaurus*, showing in its upper half that the borders are parallel. Inferiorly it expands rapidly towards the margin of the coracoid. It forms, with the semicircular coracoid, a very shallow glenoidal fossa of rectangular outline. There is no scapular crest or acromion-like process; these are altogether wanting.

Humerus. As in all Theropoda, the humerus is very weak, but perfectly distinct from the same much more massive bone in *Megalosaurus*, or the more slender but still powerful humerus in *Poikilopleuron*. The different development of the radial crest in each case affords a good characteristic.

Pelvis. The imperfect ilium shows in general, as pointed out by Philips, some resemblance to *Megalosaurus*; the proximally expanded, distally rod-like ischium seems, however, to be somewhat different. The pubis shows no obturator foramen.

Posterior limb. The femur is somewhat longer than the tibia. The head of the femur shows quite a distinct neck, the trochanter major is weaker than in *Allosaurus* and situated lower than the head, the well-developed fourth trochanter, situated at the beginning of the upper third of the femur, shows the *trochanter en crête* pattern. The shaft of the femur is somewhat curved and nearly cylindrical in section.

Comparing the outline of the fourth trochanter of *Streptospondylus* or *Allosaurus* with the figure given by Hulke for *Zanclodon* or the outline visible in *Euskelesaurus* (in the Vienna femur), and then the

[1] It is quite a common thing to find in the synsacrum of the Upper Cretaceous Dinosaurs 8–10 vertebræ, lumbosacrals, sacrals, and caudosacrals firmly united. Besides *Claosaurus* and *Triceratops* this is also the case in the sacra of two not yet described Transylvanian Dinosaurs.

[2] Careful original studies have convinced me that the type-specimens of *Poikilopleuron* and the Stonesfield *Megalosaurus* (*M. Bucklandi*) are perfectly distinct.

same part in the Senonian *Megalosaurus Bredai*, one remarks that the same sort of change and diminution as I pointed out among the Ornithopodidæ can also be traced among the Theropoda, in consequence of which I feel unable to accept Hulke's statement that in the Theropoda the *trochanter en crête* represents a more primitive type than the pendant trochanter.

Distally the femoral ectocondyle of *Streptospondylus* shows a smaller posterior projection, much like that in *Megalosaurus*, *Allosaurus*, and the bird *Apteryx*, while in *Iguanodon* and some birds (for example, *Cygnus*) this part is constructed after another fashion. The distal end of the strong tibia is one of the few fragments of limb bones preserved in the Paris specimen, but this, I regret to say, has been described and figured as *Megalosaurus*, and only the complete tibiæ of Mr. Parker's specimen show that the fragment in reality belongs to *Streptospondylus*, from which it has been separated for nearly a hundred years.

As the proportion of femur and tibia among Dinosaurs seems to be of the greatest interest, since it appears that among all Dinosaurs there exists a tendency to elongate the femur, a list of ten Dinosaurs is here given in which the proportion of femur to tibia is expressed according to the formula femur : tibia = x : 1.

Genus.	Bipedal.		Quadrupedal.	
	Theropoda.	Orthopoda.	Sauropoda.	Orthopoda.
Ornithomimus	0·58 : 1	—	—	—
Nanosaurus	—	0·84 : 1	—	—
Hallopus	0·87 : 1	—	—	—
Anchisaurus	1·02 : 1	—	—	—
Trachodon	—	1·17 : 1	—	—
Megalosaurus	1·27 : 1	—	—	—
Cetiosaurus	—	—	1·32 : 1	—
Scelidosaurus	—	—	—	1·33 : 1
Apatosaurus	—	—	1·62 : 1	—
Stegosaurus	—	—	—	1·8 : 1

(Italics indicate Triassic or primitive forms.)

A more complete list, containing 24 genera, will be given in my later paper on *Streptospondylus*.

The proximally expanded fibula of *Streptospondylus* is conspicuous on account of its slender character, especially when compared with the robust form of the associated tibia. In consequence of this disproportion it seems much more slender than in either *Creosaurus*, *Allosaurus*, or the Triassic forms. It does not show any trace of distal expansion.

In the *astragalus*, which is applied firmly to, but not united with, the calcaneum, a well-developed ascending process is always present, but never reaches so high as in *Poikilopleuron*. As in the latter animal it is applied against a projection of the tibia. I wish

Restoration of the skeleton of *Streptospondylus*, from the Oxford Clay of Oxford.

Reconstructed by Dr. Francis Baron Nopcsa from the original specimen in Mr. J. Parker's collection.
(The shaded parts represent the bones actually known.)

to refer to a former paper[1] for the phylogenetic value of the ascending process. In opposition to what is known of *Allosaurus* and *Megalosaurus*, there are in *Streptospondylus* in each foot four well-developed metatarsal bones, each bearing well-developed toes armed with claws. The claws show the carnivorous pattern.

With the superior crest of the ilium Mr. Parker's nearly complete *Streptospondylus* stood about 4 ft. 9 in. from the ground, and the Paris specimen may have been 6 feet in height; the total length of these two animals was probably 20 and 27 feet. *Megalosaurus*, we may assume, may have attained a maximum length of 30 feet.

Plate XV accompanying this notice gives a reconstruction of *Streptospondylus* as based on the study of Mr. J. Parker's fossil, and Miss A. B. Woodward has had the great kindness to make this drawing according to my directions. The large skull, the feeble but flexible neck, the weak anterior and powerful posterior limbs are well shown.

The principal differences of *Streptospondylus* and other Theropoda have already been pointed out in different parts of this paper; here I wish only to refer once more to the Sauropod-like build of the vertebral column. That the Sauropoda descended from bipedal Saurischia I intend to discuss upon some other occasion. The specific name of the only kind of *Streptospondylus* known till now is *Strept. Cuvieri* (H. v. Meyer); the horizons at which the genus occurs are the Callovian in France and the Oxford Clay at Oxford in England.

EXPLANATION OF PLATE XV.

Reconstruction of *Streptospondylus* (the shaded parts indicate the bones that are actually known).

II.—An Account of some Marine Fossils contained in Limestone Nodules found on the Mekran Beach, off the Ormara Headland, Baluchistan.

By R. Bullen Newton, F.G.S.

(PLATES XVI AND XVII.)

THROUGH the kindness of Miss Caroline Birley, of Kensington, I have been privileged to examine a collection of fossil marine shells and other organisms in her possession, which occur in drab-coloured, gritty, and siliceous limestone nodules picked up on the beach off the Ormara Headland, facing the Mekran or Baluchistan coast, 130 miles west of Karachi, by Mr. F. W. Townsend, chief executive officer of the Submarine Telegraph Service in the North Indian Ocean.

So far as the present specimens demonstrate, the nodules vary in size from two to about four inches in diameter, many of them being as round as a ball with perfectly even surfaces, to which are

[1] Nopcsa, "Synopsis und Abstammung der Dinosaurier": Földtani Közlöny, Budapest, 1901.

sometimes attached parasitic forms of modern marine life, such as *Hippothoa*, etc. When split open with a hammer these nodules are invariably found to enclose a fossil of some kind, and most frequently a shell. The condition of the fossil is nearly always that of a natural cast exhibiting internal structures, whilst external features are often preserved in the concavity of the counterpart of the nodule, thus making it possible to obtain a fairly good restoration of the original shell by pressing into it some artists' wax or gutta percha.

A similar plan for obtaining structures was successfully adopted by Professor Ray Lankester when studying the marine shells and other organic remains found as casts in the celebrated sandstone nodules of the Suffolk Crag, known as the 'Box-Stones' (Quart. Journ. Geol. Soc., 1870, vol. xxvi, p. 499). And here it may be interesting to remark that the Suffolk 'Box-Stones' of all the fossiliferous nodules found in the different formations are perhaps the most convenient for comparison with those from the Mekran Coast, since they are most likely to be of an approximate geological age. They may be collected on the beach at Felixstow, after being washed out of the surrounding cliffs, where they occur *in sitû*, or they may be obtained from the 'Coprolite-diggings' of the same neighbourhood. Fossils are much more rarely found in them than in the Mekran material, and many a nodule may be cracked open before an organism is discovered; the following genera have, however, been recognized: *Isocardia*, *Cardita*, *Glycymeris* (= *Pectunculus*), *Conus*, *Cassidaria*, *Pyrula*, *Turritella*, *Voluta*, *Mastodon*, etc.

Among the shell-remains of the Mekran nodules are *Cardium*, *Dosinia*, *Mactra*, *Arca*, *Dolium*, *Tugurium*, *Neptunea*, and *Lampusia*; the genera *Cardium* and *Tugurium* being of the most frequent occurrence. Besides these shells there is a Polyzoan encrusting the spire of *Neptunea* belonging to the genus *Membranipora*, which Mr. H. W. Burrows has kindly described for this paper. The Crustacea, represented by a crab's carapace and a species of *Balanus*, both of which are described by Dr. H. Woodward, F.R.S.; but no Echinoderms, Brachiopods, or Cephalopods were observed.

A very modern facies characterizes such a fauna as is here enumerated, the various genera being nearly all found in adjacent seas at the present day; the fauna also seems to indicate shore or shallow-water conditions of existence. But there are certain specific differences to be noted in this assemblage, which appear to suggest a relationship with Mio-Pliocene forms of the Mediterranean area and actual Indian Oceanic species. Moreover, Mr. Edgar Smith, of the British Museum (Nat. Hist.), and Mr. Cosmo Melvill, after an examination of this collection, are of opinion that the species are not represented in modern seas, although showing generic affinities with living mollusca.

With regard to the origin of the Mekran nodules, Mr. Townsend, the collector, seems to think that masses of the upper strata of the Ormara Headland break away from time to time, and so falling upon the beach become rolled and worn by the action of the sea; but it is much more probable that the nodules occur somewhere in the cliff

in situ, and like the 'Box-Stones' of Felixstow reach the sea beach as rounded ball-like bodies without the intervention of subsequent marine agencies. The present collection comprises more than eighty examples of these nodules, and I am given to understand that they are to be met with in large numbers on the Mekran Coast, yet, notwithstanding their apparent common occurrence, there seem to be no published observations upon the subject. Among the few writers who have investigated the rocks of the Mekran Coast, Dr. W. T. Blanford's[1] name stands first. He regarded these cliff deposits as of post-Nummulitic age, and named them the 'Mekran Group,' describing as well their more or less flat-topped character and nearly horizontal bedding, as observed at Ras Malan, which is 2,000 feet high, Ormara, and Gwadar. In remarking upon the constitution of these beds he states that "The prevailing rock along the Makran Coast is a pale grey clay, more or less indurated, occasionally intersected by veins of gypsum, usually sandy and often calcareous, occurring in beds of great thickness. With this clay are interstratified bands of shelly limestone, calcareous grit, and sandstone, but these usually form but a small portion of the mass, although their greater hardness makes them conspicuous at the surface." An abundant marine fauna is said to characterize the various beds of the Mekran group with such genera as *Ostrea*, *Pecten*, *Arca*, *Cardium*, *Lucina*, *Cerithium*, *Turritella*, and *Natica*; besides Echinodermata, Corals, and Foraminifera (*Operculina*), but without Brachiopods or Cephalopods. Dr. Blanford further states that "the general facies of the Mekran fauna is utterly different from that of the Lower Tertiaries; the commonest and most characteristic fossils of the Nummulitics are Foraminifera, especially *Nummulites* and *Alveolina*; the most abundant shells in the Mekran Group are barnacles, oysters, and scallops. No junction of the two series has hitherto been observed, but it may be safely asserted that the Mekran Group is newer than the Nummulitics, for while the fauna of the latter appears to be nearly or entirely extinct, at all events in the shallow seas near the coast, several of the Mekran fossils appear identical with the species found living, in water of moderate depth, along the shores of Baluchistan and the Persian Gulf."

Capt. A. W. Stiffe,[2] who next visited the Mekran Coast, found the calcareous deposits to be almost entirely composed of marine organic remains, in parts distinct and perfect, forming a shelly breccia and passing into a more or less compact limestone. His fossils were submitted to Mr. Etheridge, who reported as follows:—"The shells appear to me to be of Miocene age, although all are mere casts, and therefore it is very unsafe to pronounce definitely as to their age. I cannot determine them to belong to the modern species of the Persian Gulf. The cast of *Conus*, *Cypræa*, and *Ostrea* are certainly not those of existing species; and the mass of shelly breccia

[1] Records of the Geological Survey of India, 1872, vol. v, pp. 41–45.

[2] Quart. Journ. Geol. Soc., 1874, vol. xxx, pp. 50–53, with sketch-map of Mekran Coast.

containing *Dentalium*, *Cardita*, *Astarte*, *Venus*, *Trochus*, *Arca*, and *Tellina* I believe to be of more modern date, if not recent."

In his classical work on "Eastern Persia" Dr. Blanford[1] again referred to the Mekran deposits as belonging to a "late Tertiary formation," inserting a list of determinations by Mr. Etheridge of a collection of fossils found by Dr. Day at Gwadar, which were considered as exhibiting "a very late facies, and may even be Pleistocene." This included *Dolium* sp., *Natica Lamarckiana* or a closely allied form, *Cerithium torulosum*, *Turritella* sp., *Fissurella* sp., *Jouanettia*, *Tellina edentula*, *Venus* sp. near *plicata* and *rugosa*, *Cytherea* sp. near *lyrata*, *Astarte* (?) sp. allied to *Circe corrugata*, *Diplodonta* sp., *Cardium*, two sp., one near *C. papyraceum*, *Chama* sp. near *C. isostoma*, *Arca*, four or five species, one of which is *A.* (*Parallelopipedum*) *tortuosa*, the others allied to various recent forms, *Pectunculus*, two species, one allied to *P. pectiniformis*, the other to *P. lividus*, *Pecten* somewhat resembling *P. pyxidatus*, *Ostrea* sp., *Temnopleurus*, two sp., *Eupsammia* sp. (coral), *Mæandrina* sp., *Operculina* sp.

A further allusion is made to the Mekran Group in Medlicott & Blanford's work on India,[2] with the remark that it "appears to be of later age than the Miocene Gaj Beds"; and, again, on the evidence of the Echinoidea (*Temnopleurus simplex*, Duncan & Sladen, etc.) found in these deposits Dr. P. M. Duncan and Mr. W. P. Sladen[3] came to the conclusion that the beds were younger than the Gaj Series (=Miocene) of India, and consequently might be regarded as Pliocene. In Mr. R. D. Oldham's edition of Medlicott & Blanford's "Manual," 1893, p. 316, it is stated that "The Mekran Group is of shallow-water marine origin and abounds in Mollusca, Echinoderms, etc., many of the species being apparently the same as living forms. The Echinoderms alone have as yet been examined in detail; they belong, without exception, to living genera, while most of the species are very closely allied to recent forms, and one species alone is doubtfully identical with a Gaj form. The general facies of the fauna is distinctly Pliocene." Lastly, Capt. Stiffe, in exhibiting "a fossil *Cardium* (?)" before the Geological Society in January, 1899, which had been found at the foot of the Cliffs of Ormara, stated that "the fossils in the clay are difficult to find, and probably are generally enclosed in nodules of the clay somewhat altered, as in this specimen." (Abstracts Proc. Geol. Soc. London, 1899, No. 701, pp. 31, 32.

With the exception of the extracts just quoted, and which deal exclusively with the fauna of the 'Mekran Group,' there are no monographs on the invertebrate fossils of the Tertiary formations of India which render much assistance in the determination of the specimens from the Mekran nodules. It may be as well, however,

[1] "Eastern Persia," 1876, vol. ii, pp. 462–465.

[2] "A Manual of the Geology of India," 1879, vol. ii, pp. 470, 471.

[3] "The Fossil Echinoidea from the Mekran Series (Pliocene) of the Coast of Biluchistan and of the Persian Gulf": Mem. Geol. Surv. India, Pal. Indica, 1886, pp. 369–382, pls. lvi–lviii.

to refer briefly to the remaining literature which treats of the Tertiary invertebrates of other parts of India.

One of the earliest papers is that by James de Carle Sowerby,[1] who determined Capt. Grant's Tertiary collections from Cutch as belonging to Nummulitic and later Tertiary horizons; this was succeeded in 1853 by D'Archiac & Haime's memoir[2] on the Nummulitic fossils of India, which unfortunately is not a reliable work, since Secondary and Tertiary specimens are mixed up together and regarded as coming from the same series of beds.

Then followed Stoliczka's[3] work on the Tertiary Crabs of Sind and Cutch; Duncan's[4] on the Fossil Corals of Sind; the Tertiary Echinoids of Western Sind being monographed by Duncan & Sladen[5] between 1882 and 1886; lastly, we have the very important treatise on the Miocene Fauna of Burma written by Dr. Fritz Noetling,[6] containing a large number of plates illustrative of the fossils (chiefly Mollusca) of that region, accompanied by a voluminous text.

In describing this fauna Dr. Noetling was able to trace, in a general way, its correlation with the Miocene of Java and the Miocene (Gajian) of Western India. He believed also that the present Indian Ocean fauna was directly derived from the Miocene faunas of India, Burma, Sumatra, and Java. Until more is known of the Tertiary Mollusca of Western India and its connection with the shells now living in the surrounding seas it would be premature to definitely state the age of the Mekran nodules, although we may assume, provisionally, that they are Pliocene and probably synchronous with the beds of the 'Mekran Group,' which Dr. Blanford first recognized as younger than either the Eocene or the Miocene periods. In support of this horizon we have the undoubted presence of a northern genus, *Neptunea*, associated with forms that belong to a torrid or warmer sea, an exactly similar phenomenon being known in the Pliocene beds of Europe, and that without any apparent disturbance of the deposits containing them. Further, in comparing this limited fauna of the Mekran nodules with either the Burmese Miocene fossils described by F. Noetling, or the specimens monographed by Dr. K. Martin from the Upper Tertiary beds of Java, there is insufficient evidence to prove a similarity in facies so as to suggest its correlation with the faunas of those two sets of deposits.

It would have been interesting to have compared the fossils of the present collection with the original specimens of the so-called

[1] Appendix to Capt. Grant's "Memoir to illustrate a Geological Map of Cutch": Trans. Geol. Soc. London, 1840, ser. II, vol. v, pp. 289–329, pls. xxiv–xxvi.

[2] "Description des Animaux Fossiles du Group Nummulitique de l'Inde," 1853–1854, 2 vols., plates and text.

[3] "Observations on Fossil Crabs from Tertiary Deposits in Sind and Kutch": Mem. Soc. Geol. India, Pal. Indica, 1871, pp. 16, pls. v.

[4] "Sind Fossil Corals and Alcyonaria": ibid., 1880, pp. 110, pls. xxviii.

[5] "Tertiary Echinoidea of Western Sind": ibid., 1882–1886, text and plates.

[6] "Fauna of the Miocene Beds of Burma": ibid., new series, 1901, vol. i, pp. 378, pls. xxv.

'Mekran Group,' referred to in the foregoing literature, but, unfortunately, I have not been able to trace them either in the Museum of the Geological Society or in the British Museum, and I can only conclude that they may possibly be among the Indian Survey collections at Calcutta.

As it seems fairly apparent that no previous writers have called attention to the occurrence of these fossiliferous nodules, it is to be hoped that the present communication may be of sufficient interest to induce the authorities of the Indian Geological Survey to re-examine the rocks of the Mekran coast, with the view of discovering the exact position of the bed whence the nodules were derived, so that its relationship to the other deposits of the Mekran Group could be properly established.

DESCRIPTION OF THE SHELLS.

Lamellibranchia.

Arca Blanfordi, n.sp. (Pl. XVI, Fig. 5.)

Shell subquadrate, ventricose, arched, with an angulate, truncated, deep posterior side, the anterior area being rounded and oblique; umbones subcentral, rounded, strongly incurved; surface radiately ribbed and sulcated; ribs about 27, with depressed summits, angulated margins; surface transversely striated.

Dimensions.—Of moderate-sized right valve: umbono-ventral, 45; antero-posterior, 45; diameter of valve, 20 mm.

In its contour and general radiate appearance this species resembles *Arca rhombea* of Born, found off Ceylon and the Chinese seas, and which also occurs in the raised beach deposits of Karachi, India. It differs, however, in the valves being more rounded and arched, besides showing an absence of nodulous ornamentation on the ribs, which is especially developed on the anterior half of *A. rhombea*. The specimen figured is taken from a wax squeeze of a fairly well-preserved right valve found in one of the nodules, showing the more elevated region partially covered with costæ, the ventral area being stripped of the shell, thus exhibiting an impression of the extremely fine and close longitudinal striæ which adorn the internal surface of the valve, and which extend to within a short distance of the margin.

This shell is named in honour of Dr. W. T. Blanford, C.I.E., F.R.S., a former Director of the Geological Survey of India, and one of the earliest writers on the geology of the Mekran Coast.

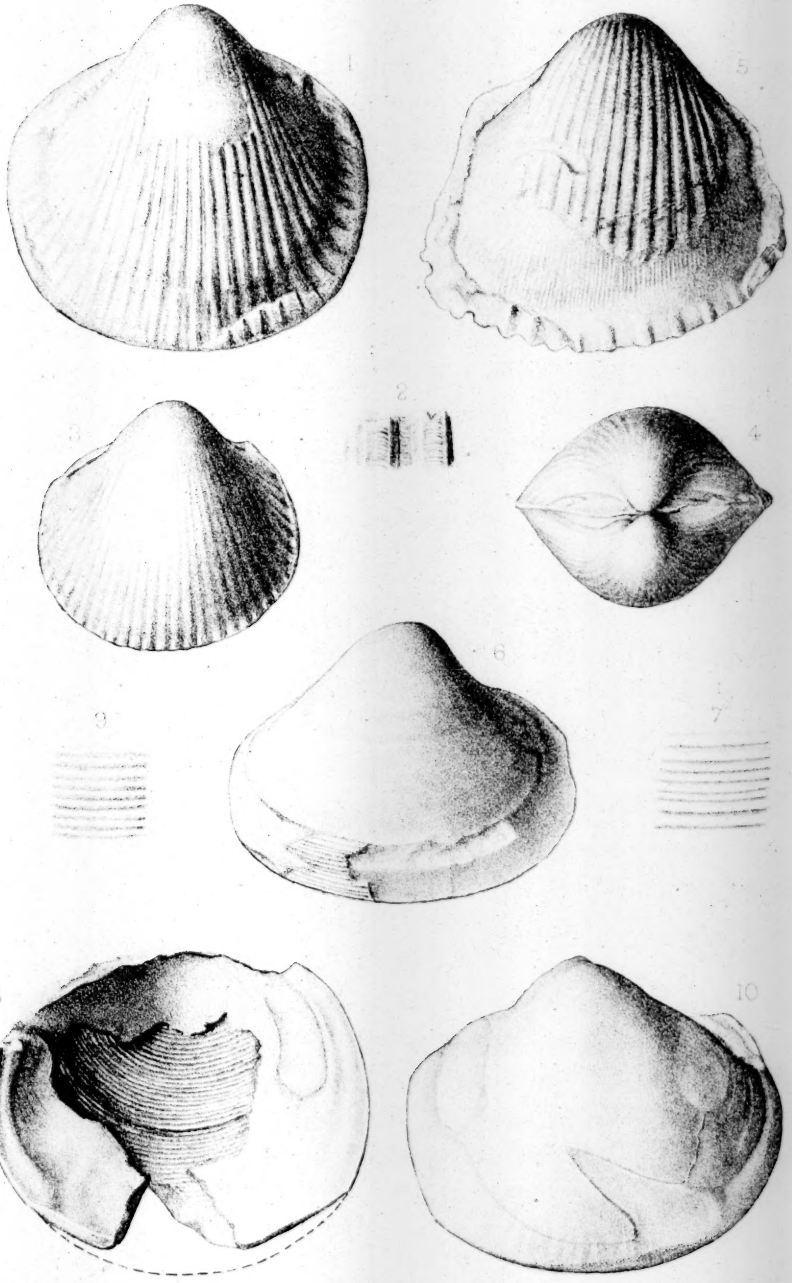
Examples.—Only three or four specimens in the collection.

Mactra mekranensis, n.sp. (Pl. XVI, Figs. 6, 7.)

Shell subtriangularly ovate, cordiform, moderately convex, obtusely angulate posteriorly; umbones nearly central; sculpture consisting of narrow, depressed, smooth, concentric banding of equal width, each band separated by an extremely narrow sulcation.

Dimensions.—Right valve: umbono-ventral, 40; antero-posterior, 47; diameter, 10 mm.

The specimen referred to this form is represented by a right valve, being mainly an internal cast, yet retaining a small patch of original



H. M. Woodward del. et lith.

West, Newman imp.

Tertiary Shells in nodules
from the Mekran Coast.

shell structure on the postero-ventral region, which well illustrates the smooth, narrow-banded character of the sculpture. I have not been successful in discovering a shell which is suitable for comparison with this species, either among modern or fossil forms, its chief characters having reference to the triangularly oval shape and the regular concentric banding which ornaments the valve.

Example.—One specimen only in the collection.

CARDIUM MELVILLI, n.sp. (Pl. XVI, Figs. 1–4.)

Shell globose, nearly equilateral, radiately costated; costæ about 37, depressed, angulated at the sides, separated by narrow, deep interspaces about one-half the width of the ribs (as seen near the ventral margin); umbones rounded, incurved, subcentral.

	Largest.		Smallest.
Dimensions.—Umbono-ventral	48	...	35 mm.
Antero-posterior	48	...	35 „
Diameter (closed valves) ...	38	...	28 „

This is one of the most abundant shells found in the Mekran nodules, though always occurring as internal casts. Some original costal structure still remains on the ventral area of the larger specimen selected for illustration, showing that the ribs have rather wide flattened summits covered with delicately vaulted surface lineations, angulated sides, and divided by narrow sulcations which are closely and concavely striated within. In its well-arched and globular form and the great number of its ribs this species resembles *C. asiaticum* of Bruguière and *C. multispinosum* of Reeve, both living Pacific shells, though differing in the structural details of the costæ. In *C. asiaticum* the costæ are more elevated and narrower, besides being sharply lamelliform on the posterior region of the valves; and instead of lineations the surface exhibits a minutely granulate structure. The ribs in *C. multispinosum* are more rounded, besides being numerously spined with small projections. I know of no Miocene or Pliocene shell which suggests affinities with this species.

The species is named after Mr. J. Cosmo Melvill, M.A., F.L.S., who is one of our principal authorities on the modern conchology of the Persian Gulf.

Examples.—Numerously represented in the collection.

DOSINIA sp. (Pl. XVI, Figs. 8–10.)

This shell is represented by a fractured left valve which exhibits both internal and external characters, the former including parts of the anterior and posterior surfaces, with complete margins, and giving good views of the adductor scar markings; through the broken surface of the centre of the valve the typical concentric lineations of this genus are well exposed. The other half of the nodule contains a natural cast of the valve showing impressions of the muscular markings and the pallial line with its conspicuously lanceolate, triangular sinus.

It is not possible to say more in connection with the specimen than that it somewhat resembles the European species *D. exoleta*, which is similarly orbicular, besides agreeing in general dimensions;

in sculpture characters, however, the Mekran specimen may possess more regular striations.

Dimensions.—Left valve; umbono-ventral, 50; antero-posterior, 50; diameter, 10 mm.

Examples.—There is only one specimen in the collection.

Gastropoda.

NEPTUNEA BURROWSI, n.sp. (Pl. XVII, Figs. 5–7.)

Shell turreted and fusiform, with a tricarinate body-whorl, which terminates anteriorly in a narrow straight canal. Upper surface of whorls oblique, slightly excavated, and furnished with rounded bicarinate margins; lower surface of whorls narrow, vertical, excavated, and unicarinate; shell structure closely, minutely, and spirally funiculate.

Dimensions.—Height, 37; diameter, 23 mm.

The test of this specimen is encircled throughout with regular narrow cord-like costellæ, separated by microscopically narrow sulcations, and crossed by fine and slightly curved striations of growth. There are ten costellæ on the oblique sutural region of the body-whorl, and six on the vertical surface of the penultimate whorl, these being margined above and below by a double row of more prominent ones, whilst the upper oblique region of the same whorl bears about eight costellæ. No varices or longitudinal costæ are present such as characterize the shells of the Muricidæ. There is no doubt that the Mekran shell bears a strong resemblance to some of the carinate forms of *Neptunea* which Searles Wood long ago described from the English Crag deposits as varieties of *Trophon antiquum*, Linnæus (see Mon. Pal. Soc., 1848, pl. v, figs. 1*a*, 1*b*), and which show a very similar funiculate shell-structure, i.e., var. *jugosum*. Moreover, the occurrence of *Neptunea* itself, which is more characteristic of boreal than warmer climates, in association with genera that belong essentially to warmer seas as are found in the Pliocene formations of Europe, would tend to prove that the Mekran nodules are of Pliocene age.

The specimen shows both cast and shell structure, the left of the spire being partially enveloped by a parasitic Polyzoan belonging to the genus *Membranipora*. The protoconch is unfortunately not preserved. I have named this interesting specimen after my friend Mr. H. W. Burrows, F.G.S., who for many years has studied the Crag fauna, and who is good enough on the present occasion to confirm my generic determination of this shell.

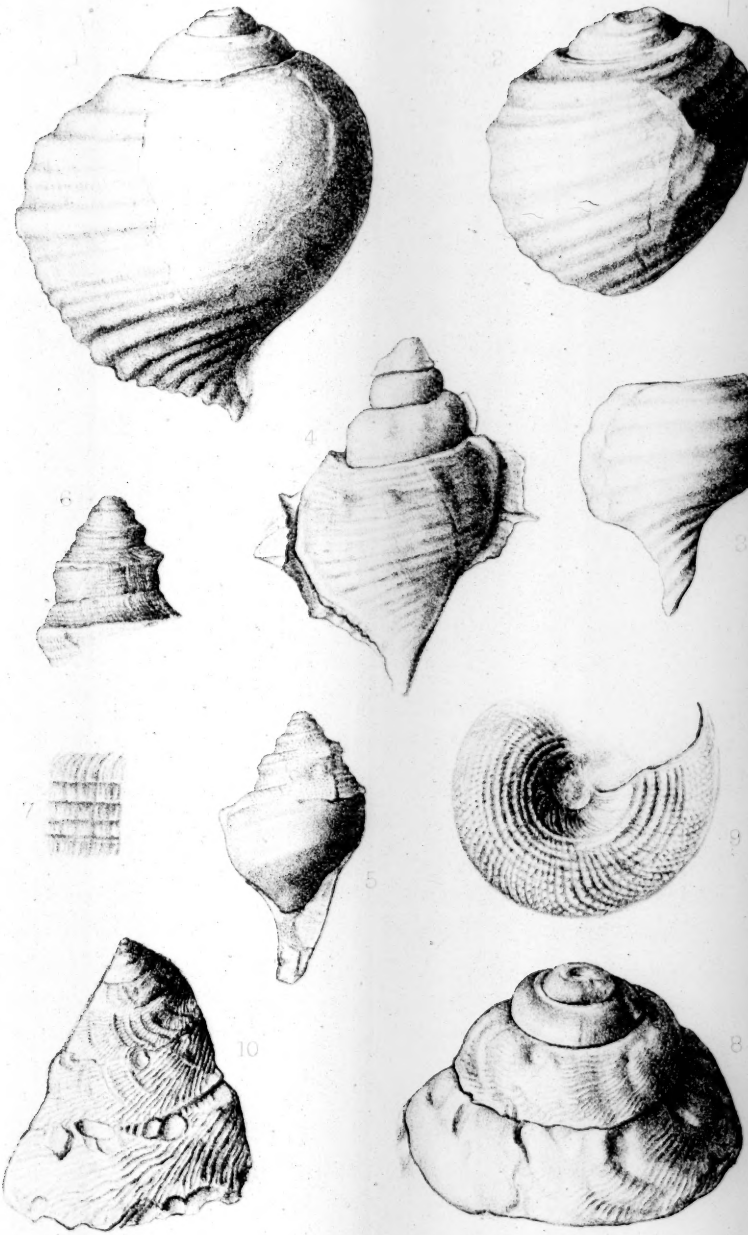
Examples.—One specimen only in the collection.

LAMPUSIA cf. AFFINIS, Deshayes. (Pl. XVII, Fig. 4.)

Triton affinis, Deshayes: "Expédition Scientifique de Morée, 1833, vol. iii (Zoologie), p. 188, pl. xxii, figs. 23, 24.

Triton corrugatum, Hörnes: Foss. Moll. Tertiaer-Beckens Wien, 1852, p. 205, pl. xx, figs. 1–4; *non* Lamarck.

There are several natural casts of this shell, all giving dorsal views and appearing to be related to *Triton affinis* of Deshayes,



G. M. Woodward del. et lith. West, Newman imp.

Tertiary Shells in nodules from the Mekran Coast.

from the Upper Tertiaries of Greece, Italy, France, and Germany. Strong spiral costæ ornament the body-whorl, and a series of distant nodular tubercles surround the obtusely carinate margin, with evidence of a second obtuse tubercled margin below. The shell shows also the varixed labrum with a corresponding varix on the other side extending up the penultimate whorl. Except for their want of sharpness the Mekran casts resemble fairly closely those examples from the Vienna Basin Miocene deposits figured by Hörnes under the name of *T. corrugatum*.

Dimensions.—Height, 50; diameter, 33 mm.

Examples.—There are five very good specimens of this shell.

Tugurium Mekranense, n.sp. (Pl. XVII, Figs. 8–10.)

Shell conical; whorls five or six, flattened, ornamented with numerous closely set, oblique, elevated, and rounded riblets, crossed by a series of equidistant, oblique, rather swollen growth ridges; suture distinct, and bearing agglutinations; base umbilicated, slightly concave, and furnished with a reticulate spiral sculpture.

Dimensions.—Height, 30; diameter, 50 mm.

This is one of the most abundant shells of the Mekran nodules. In sculpture it is very similar to *Xenophora crispa* of König, a species found in the Italian Pliocene, and which exists in the Mediterranean at the present day, although in that species the oblique striations of the upper surface of the whorls are coarser, more crenulated in structure, and considerably less regular in arrangement.

Again, *T. mekranense* is in no way related to *X. infundibulum* of Brocchi, also from the Pliocene of Italy, which is of larger size, imperforate, much excavated at the base and without basal reticulate sculpture; the upper surface of the whorls is also much more coarsely ornamented. On account of the umbilication and the fact that agglutinations take place at the suture this form is recognized under Fischer's name of *Tugurium*.

Examples.—Very numerously represented.

Dolium Townsendi, n.sp. (Pl. XVII, Fig. 1.)

Shell thin, ovally globular, ventricose; volutions about five, penultimate and earlier whorls compressed, and showing obtuse median angulation, suture sunken, spire moderately elevated; body-whorl prominently sculptured with 15 or 16 rounded, ridge-like, spiral costæ of more regular occurrence below than above, and divided by depressed interspaces of variable widths which are sometimes faintly ridged in the centre; the postero-central rib is thicker and more important than the others.

Dimensions.—Height, 55; diameter, 47 mm.

The somewhat irregularly disposed costæ of this shell seem to separate it from other species. Beneath the rounded sutural margin of the body-whorl occurs a fairly wide excavated space followed by three prominent costæ and a fourth obscure one, all of which are separated by narrow interspaces; then follows the postero-central rib, which is stronger and thicker than the others. After the postero-central rib occurs a similar width of interspace as is found

above, then succeed five rounded ribs extremely close together with very narrow interstices, these being succeeded by a series of five or six more prominent and more widely separated ribs which are nearly equidistant from each other.

This species is represented by only one shell, showing external dorsal characters. The vacant space on the body-whorl indicates a considerable absence of shell structure, although the sculpture details are well preserved in the neighbourhood of the aperture and the base. It appears to differ from other species, both fossil and recent, in the possession of a prominent postero-central rib and the general irregularity of the rib system.

The specific name of this shell is given as a slight acknowledgement to Mr. F. W. Townsend for having collected and sent to London so interesting a collection of specimens illustrative of the geology of the Mekran coast.

Examples.—One specimen only.

DOLIUM cf. HOCHSTETTERI, K. Martin. (Pl. XVII, Figs. 2, 3.)

Dolium Hochstetteri, K. Martin: "Die Tertiärschichten auf Java," 1879–80, p. 39, pl. vii, fig. 8.

It is interesting to find in this collection two examples of a *Dolium* which show a greater regularity of sculpture details than was observed in *D. Townsendi*. These possess a system of ribbing which strongly resembles what is present in Martin's *Dolium Hochstetteri* from the Upper Tertiaries of Java, and which approaches it also in general contour. The chief difference is probably the occasional presence in the Mekran specimens of an obscure median rib between the more prominent ones, which are not observable in Martin's figures. Among living shells this form of *Dolium* is related to *D. costatum* of Menke and Lamarck's *D. maculatum*, both well-known Indian Ocean species. The smaller of the two shells consists only of the body-whorl and the twisted anterior prolongation. The dorsal diameter of the larger specimen is 35 mm.

Examples.—Two specimens.

EXPLANATION OF PLATES.

Figures are drawn natural size, except a few magnifications which are introduced to illustrate shell structures.

PLATE XVI.

CARDIUM MELVILLI, n.sp.

FIG. 1.—Right valve, showing rib structure on ventral margin.
,, 2.—Magnified view of ribs, as preserved on Fig. 1.
,, 3. } Views of a smaller specimen of the same species.
,, 4. }

ARCA BLANFORDI, n.sp.

,, 5.—Right valve, showing costæ and striated internal surface at the fracture in the ventral region: drawn from wax impression of specimen.

MACTRA MEKRANENSIS, n.sp.

,, 6.—Right valve, with small patch of sculpture.
,, 7.—Magnified view of sculpture.

Dosinia sp.

Fig. 8.—Left valve, showing partial sculpture and internal characters: drawn from a wax impression of specimen.
,, 9.—Magnified view of shell ornamentation.
,, 10.—Internal natural cast of same specimen, showing muscular scar impressions, pallial line, and lanceolate sinus.

PLATE XVII.

Dolium Townsendi, n.sp.

Fig. 1.—Dorsal view of specimen.

Dolium cf. Hochstetteri, Martin.

,, 2.—Dorsal aspect of the larger-sized specimen.
,, 3.—Smaller specimen, showing twisted columella.

Lampusia cf. affinis, Deshayes.

,, 4.—Specimen showing lateral varices.

Neptunea Burrowsi, n.sp.

,, 5.—General view of specimen, showing anterior canal, with encrusting *Membranipora* on spire.
,, 6.—Another view of same specimen, showing shell structure.
,, 7.—Magnified view of tuniculate sculpture.

Tugurium (Xenophora) mekranense, n.sp.

,, 8.—General view of specimen.
,, 9.—Basal view of another specimen, showing reticulate ornamentation.
,, 10.—Fragment of another specimen, showing external sculpturing and foreign attachments at the suture.

III.—Note on a Bryozoan attached to *Neptunea* found in one of the Mekran Nodules.

By Henry W. Burrows, F.G.S.

Membranipora Lacroixi (V. Audouin).

Flustra Lacroixii, V. Audouin: in J. C. Savigny's "Description de l'Egypte," Hist. Nat. Polypes, Planches, 1817, vol. ii, pl. x, fig. 9; Explication des Planches, 1826, vol. i, pt. 4, p. 240.
Conopeum reticulum, J. E. Gray: List British Animals British Museum, pt. i, Radiated Animals, 1848, p. 108.
Membranipora Lacroixii, G. Busk: Cat. Marine Polyzoa British Museum, pt. ii, 1854, p. 60, pl. lxix, figs. 1–3.
Biflustra Lacroixii, F. A. Smitt: pt. ii of "Floridan Bryozoa," Kongl. Svenska Vetensk.-Akad. Handl. (Stockholm), 1873, vol. xi, No. 4, p. 18, pl. iv, figs. 85–88.

For other references and synonyms, see Miss E. C. Jelly's "A Synonymic Catalogue of the Recent Marine Bryozoa, including Fossil Synonyms," 1889, pp. 162–164.

Diagnosis.—*Zoarium*, adnate.

Zoœcia, oval or ovato-quadrangular, often elongated; area (usually) coincident with the whole of the front of the cell (front 'wall' membranous in the living state). Margins thick, strongly crenulate.

Oœcia, none.

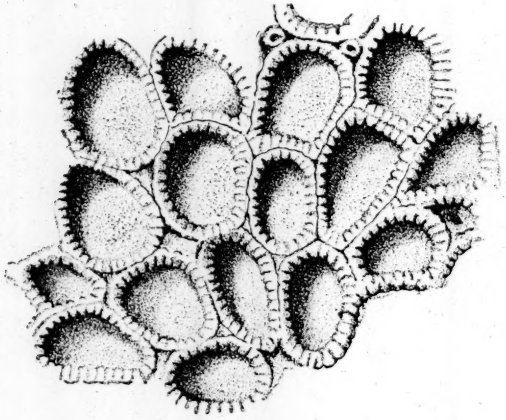
Avicularia (?), small, subcircular or roundedly triangular, situate in the anterior angles of the space between the zoœcial walls, sparsely developed.

The colony under description is attached to the apical whorls of a *Neptunea*, closely allied to the Crag *N. jugosa* (S. V. Wood), and which was found enclosed in one of the Mekran nodules.

The zoœcia are rather distorted and crowded together as they accommodate themselves to the sutures and ridges of the mollusc on which they have grown. The mature zoœcia measure about 0·20 by 0·33 mm., and are almost quadrangular, with slightly rounded angles.

This species appears to be referable to *M. Lacroixii*, as figured by Busk in the British Museum Catalogue, the most apparent difference being that the cell-walls are relatively thicker; this, however, is more noticeable in the earlier zoœcia—the later formed and typical cells have thinner walls.

The synonymy of this species is rather involved, but reference need only here be made to the most important.



Membranipora Lacroixi (V. Audouin). Enlarged 15 times.
Attached to apical whorls of *Neptunea Jugosa*, found enclosed in nodule from Mekran Coast.

Busk,[1] in the "Crag Polyzoa" (p. 31), refers *Lacroixii* (in part) to *Savartii*, Audouin.

Pergens[2] regards *M. reticulum*, *M. Lacroixii*, and *M. Savartii* as synonymous.

Later writers have considered *M. Savartii* to be a distinct species, and have included in its synonymy *Biflustra delicatula* of the Crag.

Waters,[3] in his memoir on the Membraniporidæ, points out that the 'rosette-plates' of *M. Lacroixii* and *M. Savartii* are quite different.

[1] G. Busk, A Monograph of the Fossil Polyzoa of the Crag: Palæontographical Society, 1859.

[2] Ed. Pergens, "Pliocäne Bryozoën von Rhodos": Ann. k.k. nat. Hofmuseums (Wien), 1887, vol. ii, p. 14.

[3] A. W. Waters, "Observations on Membraniporidæ": Journ. Linn. Soc., Zool., 1898, vol. xxvi, p. 679.

Miss Jelly (following Pergens) regards *M. Lacroixii* of Audouin and Busk as referable to *M. reticulum* (Linné).

Membranipora Lacroixii has a wide geographical and geological range, as the following records will show :—

Geographical distribution. British (Hincks), Mediterranean (Savigny), Florida (Smitt), St. Lawrence (Whiteaves), New Zealand (Waters).

Fossil. Coralline and Red Crag (Busk and Bell) ; Miocene and Pliocene of Austria and Hungary (Manzoni and Reuss) ; Pliocene of Italy (Manzoni, Waters, Neviani) and of Rhodes (Pergens) ; Post-Pliocene (Dawson).

Note.—The specimen is not well preserved, and the characters, in part, are somewhat obscure. The figure has been drawn from a photograph, the detail being restored.

IV.—Note on a Fossil Crab and a Group of *Balani* discovered in Concretions on the Beach at Ormara Headland, Mekran Coast.

By Henry Woodward, LL.D., F.R.S., V.P.Z.S., F.G.S.

HAVING been desired by my friend Miss Caroline Birley to examine two Crustaceans in nodules from the Mekran Coast—part of a much larger series, mostly enclosing fossil shells, described by Mr. R. B. Newton, F.G.S. (see ante, pp. 293–303)—I gladly comply with the request to add a note thereon to his paper.

The first concretion, when broken open, displays the dorsal aspect in impression and counterpart of a small crab, 5½ cm. broad by 3 cm. deep, having one long, slender, forcipated chela, imperfectly preserved, measuring nearly 5 cm. in length ; and part of one of the fifth posterior pair of feet, adapted for swimming, showing it to have been near to the family Portunidæ, to which our common shore-crabs of the genus *Portunus* belong. None of these, however, can be satisfactorily compared with the fossil crab from Ormara, which is certainly referable to another genus.

In *Portunus* the carapace is only slightly broader than deep, the latero-anterior margin having four or five serrations of equal size ; there is no prominent costal spine. In our fossil the carapace is compressed vertically and greatly expanded laterally, being armed at each angle with a prominent costal spine, while a series probably of eight (?) lesser serrations (the points of which are broken off in our specimen) fringe the regularly arched convexity of the latero-anterior border from the orbit to the costal spine, below which the postero-lateral margin is concave and the posterior border straight.

These features, added to the details of the carapace itself, enable us to refer it to the genus *Neptunus* of De Haan (see "Fauna Japonica").

In describing two new species from the Eocene of Kutch and Sind, the late Dr. Ferdinand Stoliczka wrote :[1] "The species of *Neptunus*

[1] See Memoirs Geol. Surv. India, Palæontologia Indica : "On some Tertiary Crabs from Sind and Kutch" (1871), p. 3.

are easily distinguished from the allied genera, *Scylla*, *Lupa*, and *Acheolus*, by having the last or costal spine considerably longer than the remaining eight spines of the antero-lateral margin."

The recent species are tolerably numerous; *Neptunus hastatus*, Linn., inhabits the Mediterranean, but for the most part these forms occur within the tropics, as in the West Indies, the coasts of Brazil, the Pacific, and the seas of India and Asia.

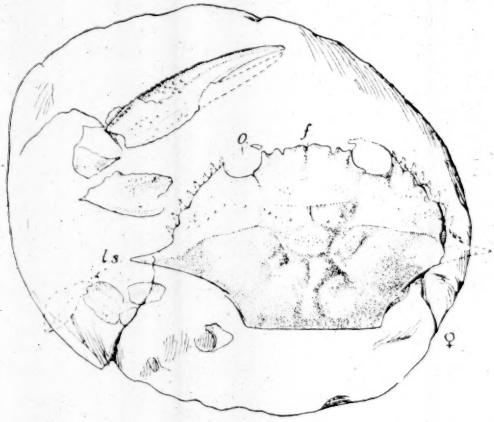


Fig. 1.—*Neptunus Arabicus*, H. Woodw., sp. nov. Newer Tertiary, Mekran Coast. Preserved in a nodular concretion which has been split open, disclosing the fossil crab in its interior. (The dotted lines indicate probable restoration of broken parts.)

Family, Portunidæ; genus, *Neptunus*, De Haan.

The late Professor Alphonse Milne-Edwards[1] described six Tertiary species, one from France, one from Sardinia, four from Northern Italy, and Herr Max Blanckenhorn has added one from the Miocene of Sinai,[2] viz.:—

Neptunus Monspeliensis, A. M.-Edw.	Eocene:	Montpellier, France.
,, *Larteti*, A. M.-Edw.	,,	Paris and Milan Museums.
,, *Vicentinus*, A. M.-Edw.	,,	Turin, North Italy.
,, *arcuatus*, A. M.-Edw.	,,	Vicentin, ,,
,, *granulatus*, A. M.-Edw.[2]	Tertiary:	Island of Sardinia.
,, *incertus*, A. M.-Edw.	,,	Vicentin, North Italy.

To these must be added—

Neptunus Wynneanus, Stoliczka.	,,	Kutch, India.
,, *Sindensis*, Stoliczka.	,,	Sind, India.

and the present specimen, which we may venture to name—

[1] In his "Histoire des Crustacés Podophthalmaires Fossiles," tom. i, 1861–5, pp. 100–118, pls. iii–vii: Ann. Sci. nat., 4e ser., Zool., t. xiv.

[2] *Neptunus granulatus*, A. M.-Edw., is recorded in a list of fossils as occurring in the Miocene of Sinai. See Max Blanckenhorn, "Neues zur Geologie und Palaontologie Ægyptens," iii, Das Miocän: Zeitschr. Deutsch. Geol. Ges., 1901.

NEPTUNUS ARABICUS, H. Woodw., sp. nov. See Text-figure (Fig. 1).

Pliocene (?) : Mekran Coast.

Description. — Carapace broader than long (5½ cm. by 3 cm.), semicircular in front; rostral border not prominently produced, 14 mm. wide, having a notch and a slight median depression in the centre; this divides two low, broad, undulated prominences, each 4 mm. wide, marking the position of the first or inner pair of antennæ; these are separated by a notch (1 mm. deep) from the next pair of double serrations, 3 mm. wide, covering the second or outer pair of antennæ; they complete the rostrum and form the inner orbital spine; the orbits are large, oval, 7 mm. wide by 5 deep; the border marked by one fissure above and apparently none beneath; then follows the outer orbital spine (probably succeeded by seven other more or less equal serrations), as indicated by dotted lines in Fig. 1, ending with the strongly developed costal spine (*l.s.*), which completes the latero-anterior angle of the carapace. The postero-lateral border curves inwards and contracts rapidly from 5½ cm. broad at the costal spine to 2 cm. behind the articulation of the fifth pair of legs. The specimen was evidently a female; therefore the posterior border of the carapace is considerably wider than would be that of a male of the same species.

Gastric region 18 mm. broad, marked by a median longitudinal depression in front, and a transverse, slightly raised line of minute pustules across the centre, separating the epigastric and protogastric from the mesogastric lobes; the metagastric and the urogastric lobes are continuous with one another, and form a slightly raised, shield-like median space produced in front into a slender, spine-like ridge 4 mm. long, which terminates at the median epigastric furrow. The hepatic region is not subdivided; it is rather depressed anteriorly, and is separated from the gastric region by a slight furrow and from the branchial region by a curved, well-defined, raised ridge, which extends from the gastric furrow to the extremity of the lateral or costal spine. The cardiac region occupies a central position behind the gastric region, being about 6 mm. broad in the centre, and is subdivided anteriorly into two well-marked triangular lobes by a median depression, ending in a pillar-like median lobe behind. The branchial region is tumid, marked by a slight double swelling next the gastric and cardiac border, where a somewhat deep furrow is formed.

The surface generally is finely granulated, with small patches of coarser granules on the proto- and metagastric lobes and on the adjacent branchial prominence, while a few minute, linear-wise tubercles mark the mesogastric and hepatic lobes.

The propodos of the fore-limb is 3 cm. long and 1 cm. broad, the surface being covered with coarse, rounded granules and scored longitudinally by two furrows which converge at the extremity of the fixed chela; the moveable claw (dactylus) is not seen; it must have been 15 mm. in length. The carpus was 8 mm. long; the meros 15 mm. long by 7 mm. broad. The basal joints are concealed by matrix.

The last or posterior pair of walking limbs in the genera

Portunus, *Scylla*, and *Neptunus* are specially modified to serve as natatory appendages, their joints being flattened and expanded for swimming, and are carried above the carapace when not used in natation, the three other pairs of simple feet serving as walking and running appendages. Only a fragmentary remnant of one of these swimming feet is preserved on the left side behind the large costal spine.

De Haan, in Siebold's "Fauna Japonica,"[1] distinguishes three equivalent subgenera, *Neptunus*, *Amphitrite*, and *Pontus*. They are all characterized by the large size of the costal spine. The subdivisions are based upon the form of the third endopodite joint of the outer maxillary feet. In *Neptunus* this joint is longer than broad, with the lower inner angle conspicuously produced, and with the upper hinder edge rounded. In *Amphitrite* the upper hinder edge of the third endopodite is considerably produced and also rounded. In *Pontus* the same joint is said to be square.

Amphitrite was accepted by Dana,[2] but united with *Neptunus* by Alphonse Milne-Edwards.[3] But the character relating to the form of the third joint seems to be subordinate.

Stoliczka had already observed (Crust. from Kutch and Sind, op. cit., p. 3) that "it is remarkable to find the *Amphitrite* form already represented in fossil species from Kutch" (as noticeable in his *N. Wynneanus*); he adds, however, that the name *Amphitrite* had been already used by Müller in 1771 as a generic name, and therefore it cannot be reinstated, but must remain a synonym of *Neptunus*.

As all the species already recorded in a fossil state have been obtained from beds older than the formation at Ormara yielding the fossiliferous concretions,[4] I have compared our crab with De Haan's figures and descriptions of recent (living) species from the Indian Ocean and the Sea of Japan. The first of these figured by him is *Neptunus pelagicus*, probably the largest and most powerful swimming-crab living, with a carapace twice as wide as it is deep, with long and powerful costal spines, a regularly arched front armed with eight equal serrations on each side; the powerful chelate fore-arms are considerably longer than the extreme breadth of the carapace. It is, however, in De Haan's subgenus "*Amphitrite*" that species are found which most closely resemble our fossil form.

In *Neptunus* (*Amphitrite*) *hastatoides*, Fabr. (De Haan, tab. i, fig. 4), the costal spines are equal to half the breadth of the carapace; two short spines are also present, one at each postero-lateral angle of the carapace behind the insertion of the fifth pair of swimming feet.

[1] Crustacea, by W. de Haan, 1850, Leyden, 4to, with 70 plates.

[2] J. D. Dana: "Classification and Distribution of Crustacea," 4to, 1853, p. 1424. Fam. IV, Portunidæ. I, Lupinæ. Genera: *Scylla*, De Haan; *Lupa*, Lh.; *Amphitrite*, De Haan; etc.

[3] A. Milne-Edwards, Hist. Crust. Podoph. Foss., 1861–5, tome i, p. 100, gives genus *Neptunus* (synonymy: *Cancer*, pars, Linné; *Portunus*, Fabr.; *Lupa*, pars, Leach; etc.). *Neptunus*, *Pontus*, et *Amphitrite*, pars, De Haan; *Lupa* et *Amphitrite*, pars, Dana: Expl. Exped. Crust.

[4] See Mr. Newton's remarks ante, pp. 296 and 300.

In *Neptunus* (*Amphitrite*) *gladiator*, Fabr. (De Haan, tab. i, fig. 5), the general features resemble our Mekran crab, but the regions of the carapace do not correspond in detail; the costal spines, although not so long as in *A. hastatoides*, are not straight but curved somewhat forward; the frontal border between the orbits has six distinct pointed teeth, not four rounded double prominences as in our specimen. The branchial furrow in *A. gladiator* also is much more arcuate.

On the whole, I find that *Neptunus* (*Amphitrite*) *tenuipes*, De Haan (tab. i, fig. 3), agrees most nearly with our Mekran crab. The costal spines are not dissimilar in length; the regions of the carapace resemble the fossil in most particulars. We are unable to compare the maxillipeds in our specimen with De Haan's figures, as we have only the dorsal aspect of the carapace exposed in the nodule.

The frontal region does not exhibit quite the same rounded and paired undulations as in our fossil crab, nor are the costal spines of equal proportion.

I prefer, therefore, to designate the fossil form from Mekran by the trivial name of *N. Arabicus*, in allusion to the Arabian Sea, which washes the shores of the Ormara Headland, where these concretions were collected.

Before quitting this subject, I may refer to another allied fossil crab with long costal spines, described by me as *Rhachiosoma bispinosa*, of which a fine series of specimens was obtained by the late Messrs. C. J. A. Meyer and Caleb Evans from the Lower Eocene of Portsmouth Dockyard (and figured and described by me in the Quart. Journ. Geol. Soc., 1870, vol. xxvii, pp. 90–92, pl. iv, figs. 3, 5; and 1873, vol. xxix, pp. 25–31, double-plate i, figs. 1–6). These specimems are of extreme interest in connection with the evolution of this group of the Brachyura, as they present a more generalized form, combining the character of the Neptunidæ in the development of the strong costal spine, not produced in the Portunidæ, but agreeing with the latter in having only five spines or serrations on the latero-anterior border instead of nine, as in *Neptunus* (see op. cit., 1873, vol. xxix, pl. i, in which the latest and most perfect examples are figured). These beautiful specimens from the Lower Eocene are preserved in the Museum of the Geological Society, Burlington House, a bequest from the late Mr. Caleb Evans, F.G.S.

Should other and more perfect specimens from the Mekran Coast be met with, and prove to have only five serrations on the latero-anterior margin, then this form might be generically separated from *Neptunus* and form, with *Rhachiosoma*, another subfamily intermediate between the Portunidæ and the Neptunidæ, as combining some of the characters found in both these groups.

Note on *Balanus tintinnabulum*, Linn.

Darwin's var. 7, *coccopoma*: "Cirripedia: Balanidæ," Ray Society, 1854, pp. 194–196, pl. i, figs. 1, 2.

The *Balani* from Ormara Headland, Mekran Coast, are contained in two nodules, one of which exhibits two or three examples only, the

other a group of ten very well preserved individuals clustered together, of which a figure is given in the text below (Fig. 2). They have been most successfully developed from the hard concretionary matrix by Mr. Richard Hall, the Museum Formatori, and the only regret is that none of the opercular valves have been preserved, or, I may say, have not been exposed to view, during the process of removing the matrix. (In specimens of *Balanus concavus* and other species from the Coralline Crag of Suffolk, I have frequently recovered the perfect set of opercular valves from the interior of the body-chamber, and, but for the hardness of the matrix, they might almost certainly be found within the interior of these fossil 'acorn shells' of the Mekran Coast also.)

Fig. 2.—Group of ten individual Balani developed out of the interior of a concretionary nodule from the cliffs on the seashore, Ormara Headland, Mekran Coast. Referred to *Balanus tintinnabulum*, Linn., var. *coccopoma*, Darwin.

The orifice of the shell (if complete) would have been enclosed by these moveable valves, i.e. by a pair of tergal and two scutal valves, upon the characters of which the species could at once have been determined. We have, then, only the shell-walls, composed of a carina, a rostrum, two rostro-lateral and two carino-lateral compartments, which, with their interlocking radii and alæ, enclose the body-chamber on every side, the lower surface being protected by the *basis* (not visible), which varies greatly in different genera, as indeed do also the walls of the shell itself.

After a careful comparison of the specimen with Charles Darwin's beautiful plates and descriptions of the sessile forms of Cirripedia (Balanidæ, Ray Society, 1854), I am led to conclude that the nearest species to our fossil is *Balanus tintinnabulum*, Linn., and of its many varieties probably Darwin's (var. 7) *coccopoma* best represents it, its form being globulo-conical, orifice small, walls rounded, generally smooth, thick (colour *x*). Some of the compartments show, in addition to lines of growth, fine wavy raised plicæ or parallel striæ, but for the most part lines of growth are alone visible.

V.—The Recent Geological History of the Baltic. Part I: The Litorina Sea.

By Sir H. H. Howorth, F.R.S., F.G.S.

THE recent history of the Baltic involves problems of great interest and importance, and promises to afford considerable help in solving the mysteries of the later geological changes in Western Europe. It is therefore worth a closer study than has been extended to it in this country. Perhaps I may be permitted to condense in the Geological Magazine what has been written about it in late years by the Scandinavian geologists, and to add some inferences of my own. I am especially indebted to De Geers and Munthe, the latter of whom has written quite an ideal monograph on one section of the story in the Bulletin of the Geological Institution of the University of Upsala, vol. ii.[1]

The most conspicuous feature of the Baltic compared with other seas directly communicating with the ocean, and in which it resembles a lake, is the slight salinity of its water, while its upper waters differ in this respect very sensibly from its lower ones.

"In the Gulf of Bothnia, at the time when the river-flow is greatest, the surface water is so little salt as to be quite drinkable, its specific gravity being as low as 1·004. It is said to contain at Christmas, when its fresh-water supplies are largely frozen, six times as much salt as at Midsummer, showing that when the river supply is at its lowest its place is taken by a reflux of salt water from the outside ocean. . . . . At Kiel, if the direction of the prevalent winds in Autumn be such as to maintain a strong surface out-current, and consequently a very strong inward under-current, as happens in some years, the maximum of salinity will present itself at that season, otherwise Meyer found that the specific gravity of the water at Kiel ranges from about 1·0182 in Summer to 1·0142 in Winter, the latter showing about half the quantity of salt in sea water." (Encyc. Brit., iii, 297, article *Baltic.*)

The degree of salinity of the waters of the Baltic decreases very much, as we should expect, as we leave the ocean and get nearer to its inner recesses. The following is a useful table compiled by Munthe from the best official sources, and showing the average percentage of salt at different places in the Western Baltic going eastwards. The figures are taken from actual observations.

Skagens Rev	2·96	Darsser Ort	1·06
Laesö Trindel...	2·49	Gjedsör Rev	1·01
Kobbergrunden	2·32	Lappegrunden	1·41
Anholts Knob...	2·10	Northern part of Oresund	1·25
Schulz's Grund	1·93	Copenhagen	1·21
Samsö Belt	1·55	Drogden	1·08
Kiel...	1·60	Lohme (Rügen)	0·81
Poël, off Wismar	1·24	Christiansö, N. of Bornholm	0·78
Warnemünde	1·18	Hela (West Prussia) ...	0·72

Continuing the investigation further east, for which we have not the same precision of testimony, Munthe, from considerations

[1] "Preliminary Report on the Physical Geography of the Litorina Sea," pp. 1–38.

dependent on the distribution of the mollusca, has calculated the position of the isohalinic line, or line of equal saltness, for the percentage of ·07, ·06, ·05, ·04, and ·03 respectively, at various points of the Eastern Baltic from the island of Gotland to the upper reaches of the Bothnian Gulf.

These figures show that between the Cattegat, where the ocean is close by, and the upper part of the Bothnian Gulf the degree of salinity in the Baltic decreases gradually from 2·96 per cent. to ·03 per cent. This distribution of salt in its waters has naturally had a great effect upon the marine molluscan fauna of the Baltic, and also has affected their size and caused them to become distorted. To this interesting issue we will now turn. For the purpose of investigation the Baltic may be divided into two sections by a line drawn a little to the east of the island of Bornholm, and we will at present limit ourselves to that section of the sea (much its larger portion) lying to the east of such a line.

The poverty of the living molluscan fauna of this part of the Baltic is phenomenal. That fauna is, in fact, limited to the following shells:—

(1) *Tellina balthica*, var. *a* and *b*. The form found in the Baltic is the original type. It also occurs in the Southampton Water and in the Orwell estuary. Löven deemed it a degenerate form of *T. solidula*, due to the brackish conditions in which it lives. Jeffreys says it is a hardy mollusc, accommodating itself to all kinds of temperature and all kinds of water, from nearly fresh to the saltest.

(2) *Mytilus edulis* (a dwarf form).

(3) *Cardium edule* (also a dwarf form).

(4) *Mya arenaria*.

(5) *Balanus improvisus*.

(6) *Paludinella balthica* (a distorted form; it was formerly called *Hydrobia ulvæ*). Under the latter name Jeffreys calls attention to the distinction of this species from the rest of the *Hydrobiæ* in that it loves brackish water, in which it in fact lives in the Thames. Elsewhere he says that it is never found out of the reach of the tide.[1]

(7) *Neritina fluviatilis*, of which Munthe says that it is found at Landskrona in water with 1·2 per cent. of salt, that it lives in slow rivers, streams, and lakes, but that a dwarf variety has been described by Nilsson inhabiting the shores of the Baltic and adhering to seaweeds and stones, sometimes at a distance from the mouth of any river, and living in company with the common mussel and a few other decidedly marine shells (id., p. 54). In this case the dwarfing has doubtless been caused by the water being too salt instead of too fresh for the mollusc to adequately thrive.

[1] In regard to this mollusc a note of Jeffreys is curious. It seems it has been found in salt springs and marshes in the Ain and Jura, and he thinks this may indicate there an ancient estuary of the Rhone (Brit. Con., v, pp. 208–9).

In addition to these molluscs we may mention as also living in the Eastern Baltic the Bryozoan *Membranipora pilosa* (var. *membranacea*). Among the molluscs here enumerated two are very recent additions to the Baltic fauna, and have never occurred in the raised beaches or shell-beds. These are *Mya arenaria* (the 'clam' of the American writers) and *Balanus improvisus*. The *Mya* is now quite a common shell in the Eastern Baltic, and Lyell as long ago as 1835 noted the remarkable fact that it was not found in any of the shell-beds (Phil. Trans., 1835, pt. 1). It has no doubt migrated from the Cattegat, and it is singular that it did not do so before, for, as G. Jeffreys says, "it is found living in sand at low water, chiefly in estuaries where there is an admixture of fresh water with the sea." He says further, "its capability of living in brackish and even fresh water is well known" (Brit. Conch., iii, 65, 66). The second recent addition is the acorn-shell, known as *Balanus improvisus*, which has occurred at Reval, Helsingfors, and in the Gulf of Finland, and may have been introduced on ships.

Putting aside these two recently imported forms, which are irrelevant to the purpose of this paper, the other species above mentioned are all found in the shell-beds and recent deposits of the coasts of the Eastern Baltic.

In regard to the effect which the slight salinity of the waters of that sea has had on the size of the shells, Munthe has shown how its mussel (which is true also of its cockle) diminishes rapidly as the water becomes fresher. Thus he gives the normal length of the mussel in different parts of the Baltic in the following table:—

	mm.
Kiel	110·0
Bay of Travemünde	84·0
Between Moen and Falsterbo	64·0
Rügen	52·4
Gotland ... ... (probably too little)	*c.* 40·0
Stockholm Archipelago	43·0
Aland	*c.* 35·0
Ulfön, the innermost known Swedish locality	22·5
Stanggrund, the innermost known Finnish locality ...	21·0

It seems clear that the addition of fresh water to salt in more than certain proportions inevitably dwarfs or distorts the shells, and the deformity is to be found wherever marine molluscs are living under brackish conditions. It is due probably partially to the want of adequate food for the mollusc itself, and partially to the absence in the brackish water of sufficient adequate materials to build up the shell.

Let us now turn from the recent shells in the Eastern Baltic to those found in the later shell-beds on its shores.

The first person to recognize these shell-beds was Magnus Bromell, who speaks of an accumulation of *Mytilus* and *Cardium* shells near Stockholm (Lith. Suec., specimen secundum, Upsala, 1727, p. 58 et seq.).

Linnæus, in the first edition of his "Systema Naturæ," 1735, refers to the *Mytilus* accumulations in Helsingland as "humus

conchacea Helsingica," and he and others afterwards mentioned similar remains in other parts of Sweden.

Lyell, in his well-known paper in the Phil. Trans. for 1835, pt. 1, enumerated the shells he had found in these beds, which (says Munthe) is still a complete list so far as the Stockholm district is concerned. Of *Mytilus* he had also found the small white *flustra*, now so commonly attached to them, in the Baltic. He also names the Gasteropod *Neritina fluviatilis*, which lives in fresh and brackish waters. He lastly pointed out that the above-named fossil mollusca are smaller than, and in some cases actually dwarf forms of, those now living in the ocean, thus agreeing with the living Baltic shells.

The enclosed character of the Baltic, which gives it its brackish quality, is an old physical feature of the sea, and it is not strange that in the accumulations of estuarine mud and the raised shell-beds on its shores we should be able to trace this characteristic of the sea back in time to a considerable distance. When we examine these beds, which consist partly of shell deposits and partly of estuarine black clays containing molluscs, we shall find that the same features which mark the living Baltic fauna have prevailed there for a considerable time. We have a similar scanty fauna, and we have also a series of shells which are more or less stunted or deformed. It is nevertheless important to remember—and the fact was not recognized by the older writers—that in these respects the living shells considerably exaggerate the conditions prevailing in the shell-beds. In the first place the latter, although poor in species, are richer than they would be if they were being deposited at this moment. In addition to *Tellina balthica*, in two forms which grade into each other as now, *Mytilus edulis*, *Cardium edule*, *Paludinella balthica*, and the Bryozoan *Membranipora pilosa*, we have in these beds two species of *Litorina*, a *Rissoa*, and a worm *Spirorbis borealis*.

In regard to four of the species mentioned as found in the later raised shell-beds of the coasts of the Eastern Baltic, it is an important fact that they no longer live there. These are *Litorina litorea*, *Litorina rudis* (since shown to belong to the sub-species *tenebrosa*), a *Rissoa* (probably a small race of *Rissoa membranacea*), *Scrobicularia piperata*, and the worm *Spirorbis borealis*. None of these shells are now found living east of the island of Bornholm, and it was concluded by Löven that the reason is that the Eastern Baltic has become less salt and in fact too fresh to admit of their living there, for they continue to thrive in the Western Baltic.

This conclusion was made a virtual certainty by the investigations of Munthe, who has shown not only that the shells last named have been completely excluded from the living fauna of the Eastern Baltic, but that the habitat of all the other marine species now living there has been driven further south and nearer to the supply of salt water, since the shells in the shell-beds were living. He has further shown that in the interval each of these shells has moved its habitat further south in a regular order and corresponding to its capacity for tolerating a more or less mixture of fresh water with salt.

Thus, in the black clays at Neder Kalix, at the very head of the Bothnian Gulf, there have occurred *Tellina balthica*, which is now found living as far north as Umea; *Mytilus edulis*, whose northern living range is Ulfön, south of Örnsköldsvik; *Cardium edule* and *Hydrobia ulvæ* (*Paludinella balthica*), which occur living at Kristinestad in Finland; and *Litorina rudis*, var. *tenebrosa*, which does not now extend beyond Bornholm. *Litorina litorea*, which is found in the raised beds north of Hudiksvall, and which Löven and Erdmann thought no longer lived in the Baltic, is still found living around the isle of Rugen.

Rissoa membranacea (var.), which now only reaches the meridian of Zealand in Denmark, and therefore the Western Baltic, has been found in the shell-beds of the Åland Islands and on the opposite coast of Sweden. *Scrobicularia piperata*, which is not known living further than Wismar Bay, has occurred in the shell-beds of North Gotland. *Spirorbis borealis*, not now found further than about Ystad, where Munthe says he found it on *Mytilus*, has been found in the shell-beds of Gotland and Upsala.

Membranipora pilosa, var. *membranacea*, whose furthest living limits are Kristinestad in Finland, and Ulfön, between Hernösand and Örnsköldsvik, in Sweden, has been found fossil by Munthe as far north as Skellefteå in company with *Mytilus* and *Tellina*, and *with the leaf of a spruce fir.*

The disappearance of *Litorinæ* and *Rissoæ* from the island of Gotland was coincident with the introduction of *Limnæa ovata* into the Baltic fauna. Löven found it in some cases associated in the shell-beds with the *Litorinas*, and he accordingly separated these *Litorina* beds into two horizons, one marked by the presence of *Limnæa* and the other by its absence. This invasion of a mollusc (the *Limnæa*), which can only tolerate a certain amount of brackishness in the water (Munthe says it lives in water with $1\frac{1}{5}$ parts of salt at Malmö), is another proof of the change in regard to salinity which has occurred in the Eastern Baltic since the later beds on its borders were deposited. This is again supported by the change which has taken place in the shells themselves, no doubt due to the same cause. Thus Lindström found that the specimens of *Cardium edule* found in the shell-beds of the Island of Gotland were larger than those now living there.

Again, Munthe says that mussels of about 52 mm. in length, corresponding to those now found at Rügen, are met with in the raised shell-beds as far north as the Skellefteå district of Sweden; and he concludes that as the fauna of these *Litorina* beds, from the most northerly part of the Bothnian Gulf down to Gotland, corresponds most nearly to that of the present Baltic between Bornholm and Warnemünde, the hydrographic character, especially in regard to salt of the Baltic *Litorina* sea, corresponded to that now existing in the district in question, which has a proportion of salt at the surface of 0·78–1·2 per cent. Elsewhere he says: "The fauna that inhabited the Baltic in the *Litorina* time from the most northerly point of the Bothnian Gulf down to Gotland corresponds most nearly

to the present fauna of the comparatively limited area of the same sea that lies between Bornholm and Warnemünde" (op. cit., pp. 5, 6).

Although it is clear, therefore, that the water of the Baltic has been growing more brackish, it is quite clear also that in the *Litorina* time it was also brackish but not to the same extent. This follows from the fact that the shells found in these beds are smaller, in some cases very much smaller, than those of the same species found in the open sea, a fact which Nathorst has shown graphically by giving us side by side figures of the Baltic *Cardium* and a *Litorina* and the same shells from the open sea. It follows also from the occurrence of two brackish-water shells in these beds—the *Paludinella balthica*, which is not a salt but a brackish-water shell, and the *Neritina fluviatilis*.

Having established that the waters of the Eastern Baltic have become less salt and more brackish in the most recent geological period, i.e. that now current, the next question that arises is as to the cause for this change. One thing is clear enough, namely, that when the *Litorinas* were living in the Eastern Baltic it covered a larger space and contained a larger quantity of water. This is plain from the raised beds in which the *Litorinas* occur, which must then have been submerged.

The true *Litorina* sea extended as far as the Sound, for the beds found virtually at the sea-level at Malmö contain *Cardiums* and *Litorinas* like those in the Baltic. The same is the case with the other side of the Sound, where at Rördam the beds occur with *Cardium edule*, *Mytilus edulis*, *Tellina balthica*, *Litorina litorea*, and *Nassa reticulata* (Nathorst, Sveriges Geologi, 277).

When we go northwards into the district of the Mälar Sea we find these shell-beds at a much higher level. Thus, Erdmann in 1868 gave a list of some of the places where clay with similar shells had occurred in the district of the Mälar Sea, with their height above the sea and their distance from the Baltic (Sver. Geol. Undersökning, i, 42) :—

	Height. Feet.	Distance from the Baltic. Myriametres.
North of Örebro	130	12–15
South of Toflasjön, near Arboga ...	100	10–12
South of Kungsör	70	9
Hasslö, east of Westerås	40	9
Enköping	30–50	7
North of Husby Church, in Nykopingslan	140	6–7
Upsala, Slottsbacken	140	5
Södertelge	40–90	3

Erdmann tells us that at Nyäker, north-east of Upsala, and at Skattmansö, a few miles north of Enköping, there have also occurred in the black clays remains of the bullhead (*Cottus scorpius*), a characteristic fish of the present Baltic. Nathorst tells us that the variety of the perch (*Perca fluviatilis*) known as the Baltic perch has been found with *Mytilus* at Stureplan, near Stockholm (see Sveriges Geologi, 271); a grey seal (*Halichœrus gryphus*) was found in Gotland, while a skeleton of the whale *Eschrichtius robustus* was

found in the same beds in 1859 at Gräsön in Roslagen (id.). The black clay resembles the buttery clay which underlies the flat levels of the lands round the Wash in East Anglia.

Erdmann tells us that this black clay is often found intercalated with the beds of gravel and rolled stones which form the covering mantle of the äsar, and in some cases this mantle is so full of shells as to be formed almost entirely of them. These banks of shells often occur without clay, and interbedded among the upper layers of the gravels and sands, and sometimes with clay which underlies them or with the so-called äkerlera which covers them. The shells contained in them are the same as those in the black clays. Erdmann gives a figure of the äs of Enköping, where these shell-beds occur on a great scale, intercalated with beds of gravel, stones, and sand. At one place the shell-bed, several feet thick, consists almost entirely of comminuted shells of *Mytilus edulis* and *Tellina balthica*. The shell-beds are separated by beds of gravel or barren clay and sand. Erdmann says that in a great cutting through this äs at Enköping there is found the typical black earth containing shells of *Mytilus edulis*. The epidermis of the *Mytilus* is singularly well preserved in many cases when the shells themselves have entirely disappeared (id., pp. 96, 97). After the work just cited was written Erdmann recognized these beds as far as Linde at the head of a lake of that name 130 miles west of Stockholm, and to a height of 230 feet above the sea-level, which, Lyell argues, shows that the Baltic has been separated for a long time, as now, from the ocean ("Principles," 12th ed., p. 194).

Again, in 1873, Gumælius reported beds with shells of *M. edulis* and *T. balthica*, ranging as high as 250 feet above the sea-level, at Bondsio, near Hernösand, at the mouth of the Angerman River, and at Avoka, near the frontier of Medelpad. Munthe apparently found these beds at Hernösand at a height of 330 feet above the sea ("Sommarkursernai, Upsala," 1893, p. 16). Gumælius mentions *T. balthica*, *H. ulvæ*, a *L. rudis* (since shown to be *rudis*), and *N. fluviatilis* as found there (G. F. i Stock. För., i, 233–4). Hisinger found the same beds at Djekneboda in Westerbotten; Freidholm, at Neder Kalix at the head of the Bothnian Gulf, at the height of at least 110 feet, and Högbom, at Löfänger, and Rickleä, from 80 to 100 feet above the sea-level. These contained fragments of *Mytilus*, and more sparsely *Tellina balthica*.

At Alnön, in 62° 28′ N. lat., Munthe found the shell-beds at the height of 77 metres, at Örnsköldsvik at 60 metres, and at Neder Kalix at 51 metres (De Geers, G. F. i Stock. För., xii, 104).

On the borders of Finland and its islands similar beds have also been found. They were first described from the Åland Islands as far back as 1767 by Tuneld, and since by Holmberg and others. Eichwald described similar deposits in a fine sand along the coast near Helsingfors, and especially mentions *Mytilus edulis* and *Tellina balthica*, both small, *Paludina balthica* (i.e. *Hydrobia ulvæ*), and *Nerita fluviatilis* as found in it. He mentions similar deposits from Vöra Kyrka in the province of Vasa, on the east of the Bothnian Gulf, as also affording fragments of *Mytilus edulis*.

Nordenskiöld and Nylander, in their monograph on Finnish shells, mention the occurrence of shell-beds of this time in the Åland Archipelago, e.g., at Söderjurmo, near Nadendal (near Abo), on Ingo Island, at Kiälkö, near Helsingfors, and at Kampen; and Schmidt has described the presence of the beds with this fauna on the shores of the Eastern Baltic. He tells us that they are found entirely covering the äsar at Karris in the island of Oesel, and also those on the Isle of Worms, while the äsar in the interior of Esthland are free from them. Similar beds, however, are found in that province, along which were once apparently inlets and gulfs of the sea up to a height of 60 feet. They cover a strip of country about 10 versts in width, and at Fickel form a tongue extending further inland. At Awaste we apparently have the old boundary of the sea forming a low terrace, and here blocks of granite are found mixed with shells of *Cardium edule*. Similar beds with the same fauna exist in the islands of Nuckö, Worms, and Dago. In North Esthland similar deposits wash old gulfs projecting into the land such as Fähna and what Schmidt calls "die ganze Baltischporter Halbinsel." They occur in long mounds of rolled gravel, sand, etc., and contain *Litorina litorea* (which is no longer found there) and other species of shells found in the neighbouring Baltic. These mounds, with the same marine fauna, are found as far east as Narva, to the east of which there are no such deposits, and this is also the eastern limit of living marine shells in the Gulf of Finland. Such marine shells, either living or fossil, also entirely fail us in the neighbourhood of Lakes Onega and Ladoga, whose Crustaceans and fish have been sometimes quoted as affording evidence of a former communication between the Gulf of Finland and the White Sea (Schmidt, Z.D.G.G., xxxvi, 266, etc.).

The island of Gotland has been fruitful in discoveries of the *Litorina* period. Lindstrom found in beds there, besides the ordinary Baltic shells, *Rissoa labiosa* (?), *Litorina rudis* (var. *tenebrosa*), and others, *Spirorbis borealis*, and the shells of *Cardium edule*, larger in size than those now living; and Munthe reports from the same horizon remains of the seal *Halichœrus gryphus*. Munthe mentions *Litorina* deposits in the north of Gotland at a height of 27 metres, and Lindstrom names them north of Wisby at 24 metres.

De Geers, Munthe, and Nathorst have given admirable maps showing the extent to which the *Litorina* sea, when at its full extent, encroached upon what is now land in the Eastern Baltic. This encroachment involved a considerable strip round the whole east coast of Sweden, beginning at Karlskrona and including the whole of the Gulfs of Bothnia and Finland and the coasts of Esthland with the islands off it, and the similar coasts of the island of Gotland. This invasion of the present land surface was especially remarkable in the district round the Mälar Sea and round the coast of Finland. It means that the general depth of the water over the area of the Central and Northern Baltic was considerably greater in the *Litorina* sea than it is now.

This, again, accounts most reasonably for the greater salinity of

that sea in ancient times than now. Lomberg has analyzed the conditions of the present currents of salt and fresh water in that sea with considerable lucidity, and makes it dependent on the present submarine banks and reefs which cross that sea and which interfere with the nether currents, conditions which would of course not be present in the same degree when the general depth of the water was greater. Thus he says: "The southern sill and the narrowing between Saltholm and Scania cause the brackish currents from the Baltic to reach right to the bottom; but as the Sound widens again these currents broaden and thin out so that their effects do not stretch so deep. Thus the bank between Malmö and Saltholm forms a complete barrier against the marine forms, the southern end of the Sound is occupied by a brackish-water fauna, and the limit between this and the deeper salt-water fauna gradually rises nearer the surface as it approaches the northern end of the Sound" (Lomberg, Meddelanden från Kong. Landb., pp. 43, 44, trans. by Bather, *Nat. Science*, xv, 269). Munthe has applied the same form of reasoning to the conditions of the Baltic in the *Litorina* time. Thus he says: "The condition of things was of course most favourable for the transfer of salt water from the Cattegat to the Baltic at the stage when the land subsidence in the *Litorina* time had reached its maximum . . . . Remembering that the Baltic basin's bottom at the *Litorina* time lay comparatively deep below the surface of the ocean, we can see that, especially at the stage of greatest subsidence, the salt currents from the Cattegat must have been able to force their way much more easily than at present, even across the bars, hidden under water, that are to be found in the district both at the boundary between the Bothnian Gulf and the Baltic and in North Quarken. As the results of the Ekman expedition in 1877 show, these hidden bars, lying now at a depth of less than 40 metres, hinder to an appreciable extent the influx of salter under-currents. This cannot have been to the same extent the case in the *Litorina* time, for the bars then lay at a considerably greater depth, viz., at a depth of about 90 and 130 metres respectively." This seems to be a quite rational and adequate explanation of the decreasing salinity of the Baltic.

In concluding this paper may I add a word about another matter of some importance. In recent years strong efforts have been made by some, and notably by Professor Suess, to show that the alleged changes of level in sea and land round the Baltic has been due to a shifting of the water-level due to aberrant influences, and not to any alteration in the earth's crust.

The evidence of the *Litorina* beds seems quite inconsistent with this conclusion, for they are neither at the same level nor do they culminate in height in a regular gradation in any direction; but on the contrary they culminate to a point, i.e. the neighbourhood of Hernösand, in the Central Baltic, from which they fall away both north and south. This is not all.

The fact that the level at which the so-called *Litorina* deposits occur increases considerably as we proceed from the Baltic towards the

Dovrefelds is further good evidence that the elevation was not uniform, but must have diminished as we travel eastward from the high mountains towards the coast. Munthe's researches prove, as he says, that the isobases for the *Litorina* deposits show a gradual rise in their level from the Stockholm district inwards towards the central districts (id., p. 11). Again, he speaks of the upheaval of the land being greatest the further one goes towards the central part of Scandinavia. This is in accordance with the conclusions of De Geers. The greatest elevation, in fact, occurs between lats. 62 and 64, from which it diminishes both northwards and southwards.

These facts seem conclusive that the shell-beds testify to an actual alteration in level of the solid crust of the earth, and not merely to a moving envelope of water.

VI.—Some Examples of Jointing in Chalk.

By Claude H. B. Epps, B.A., The College, Winchester.

(PLATE XVIII.)

THE structures described in this note occur in a large chalk-pit close to Hensting Farm, by Owlesbury, near Winchester. The east face is vertical, about forty feet high; near the bottom, along a well-marked bed of the Chalk, some deposits of gravel and clay are exposed at varying distances from each other; three of these are small, two rather larger. On the south face there is a similar deposit near the top of the pit, but this is inaccessible, and no special structure can be seen in the surrounding Chalk owing to its conversion into subsoil.

Of the two larger deposits one is almost hidden by débris, but the other shows some points of interest. It consists of a ridge of sand and clay, projecting obliquely from the face of the cliff for a distance of some eight feet, the surrounding chalk having been removed; a little digging shows that it is a true 'fossil watercourse,' not merely fallen material. In section it is roughly circular, about two feet in diameter; the greater part consists of a dark brown sandy clay showing current-bedding, with somewhat fine gravel, the grains of which are not much rounded above, and pieces of chalk and a few flints which have fallen from the roof of the channel into the stream.

The Chalk through which the underground stream once ran is fairly hard and homogeneous, consisting of the *Belemnitella quadrata* zone; it dips 5° S., but the bedding is otherwise undisturbed. Several bands of flint occur higher up in the pit, but low down there are few.

Within a distance of seven or eight feet from the deposit the Chalk shows strikingly regular joints, which form three distinct sets. The first set consists of roughly cylindrical joints, co-axial with the deposit; the second of radiating planes, perpendicular to the first set; and the third of planes transverse to the axis of the deposit. As the face of the pit is oblique to the former course of the stream the first set appear as portions of ellipses, unless the observer is

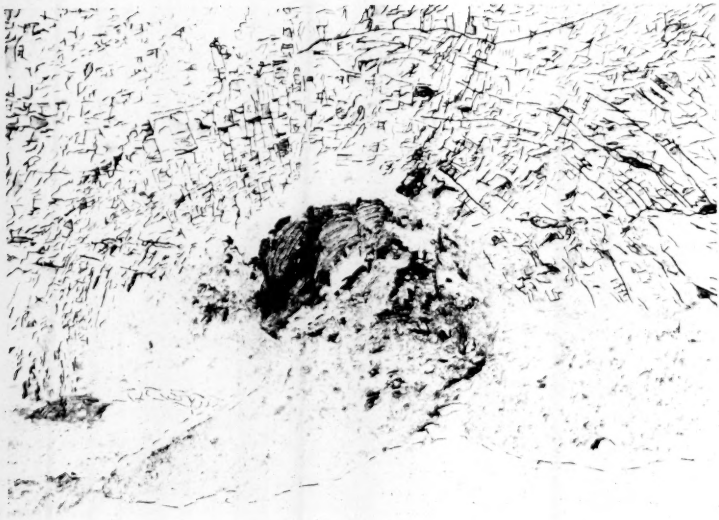


Fig. 1.

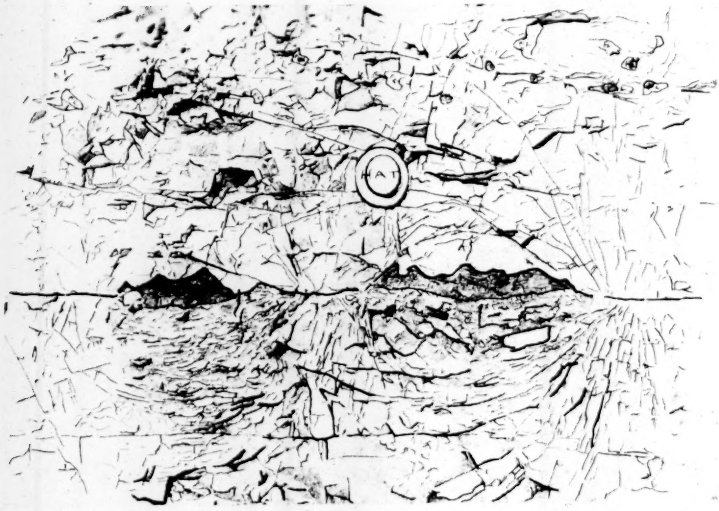


Fig. 2.

Radial jointing observed in relation to ancient watercourses in the Chalk, Owlesbury, near Winchester, by Mr. C. H. B. Epps.

placed on the axis of the deposit, when the true shape can be seen much better (see Plate XVIII, Fig. 1).

The photograph accompanying this note was taken from this axial point of view; the ridge of sand and clay is, of course, much foreshortened. (The height of section shown is about fifteen feet.) Owing to the uniformity of colour of the chalk and the fact that most of the joint faces were equally illuminated, it was necessary, in order to get a clear diagram, to go over every line visible with waterproof ink, afterwards partially bleaching the print; at the risk of making the diagram confused every line visible on the print in a good light was marked, whatever its direction.

The cylindrical joints can be fairly easily seen; the radial joints are best seen to the left of the central line; the faces formed by the transverse joints are directed towards the camera, so that the joints themselves are not visible.

A simple explanation of the formation of the three sets of joints is provided by the fact that chalk is soluble. After the channel of the stream became choked by deposit, and the waters were forced to run elsewhere (possibly through the other small channels visible on the same level), the chalk by long-continued solution slowly contracted, while beyond a certain point the gravel and clay would not contract. Under these conditions it is clear that three sets of joints would be formed round a solid rod-like axis if the contracting material were homogeneous.

Plate XVIII. Fig. 2, shows the structure of the chalk round two of the smaller deposits which occur on the same level in the pit; this photograph has been treated in the same way as the first. A similar explanation of this case seems to be possible, though its application is not quite so easy. Owing to the band-like shape of the deposits the chief joints radiate from points at the ends of the bands, looping from one point to the other, thus producing a figure somewhat like the lines of force of a simple magnet.

VII.—The Geological Physics of the Shallow Seas.

By A. R. Hunt, F.L.S., F.G.S.

SINCE the year 1871 I have been much impressed with the interest and importance of one of the byways of science, the problem of the Geological Physics of the Shallow Seas. Recent discoveries in raised beaches have brought this subject again to the front, and the object of the present paper is to plead for further inquiry by specialists.

I may briefly mention my own now antiquated papers, viz., "Notes on Torbay" (Trans. Dev. Assoc., 1878); "The Formation of Ripple-mark" (Proc. Roy. Soc., 1882); "The Action of Waves on Sea Beaches and Sea Bottoms" (Roy. Dublin Soc., 1885); and "On the Influence of Wave-currents on the Fauna inhabiting Shallow Seas" (Journ. Linn. Soc., 1884). With the exception of the Dublin paper, the MSS. were, as a matter of fact, perused by

eminent mathematicians, who kindly guarded me against any conflict between observation and theory.

It is doubtful, and indeed improbable, that anyone has carefully read all those papers, as geologists might be deterred by the technical zoology, the zoologists by the technical geology, and physicists by both. The fact was that the complex subject required the attention of first-rate specialists, and it was utterly beyond my powers to do justice to it, or even to sufficiently impress scientific men with its real interest and importance.

So far as I was personally concerned my efforts were fully acknowledged: by election in 1879 to the General Committee of the British Association, and in 1884 to the Linnean Society. But, notwithstanding this, the subject has been rather persistently ignored, and a month scarcely passes without some crusted old fallacy being repeated in print. It is, however, absolutely useless to contradict the errors in detail.

As the question of raised beaches is essentially one of marine geological physics, I am, for the reasons given above, much interested in the problems suggested by the new evidence, entirely apart from any personal opinions.

A raised beach is obviously an ancient water margin; and, according to the character of its deposits, so must have been its related submarine slope seawards. As a rule the ancient slope, or sea-bottom, has been subsequently raised and eroded to a much lower level, and were the land again lowered to its ancient beach-level, the conditions would be quite different, and the waves would merely remove every vestige of beach-deposit from the old remnant of a beach or foreshore platform. But in Ireland, we now learn, thanks to the researches of Messrs. Wright & Muff, that the present recent shingle occasionally rests on an ancient ice-scored beach platform or its equivalent, a state of things one might well have deemed impossible. However, the fact must be faced. As a raised beach is, after all, a beach, to understand it thoroughly the student must be intimate with modern beaches. In fact, a raised beach student should be geologist, conchologist, and marine engineer. Whether that combination at present exists I am not aware, but its advantage was exemplified in the case of the late Daniel Pidgeon, who from his knowledge of beaches and conchology, and being also an engineer, though not a marine engineer, at once discerned the unbeachlike character of a portion of the Hope's Nose beach-deposits. At present beaches are being keenly studied by marine engineers, with a view to sea defence works. Most of the details of the forms and depths of drowned and silted valleys are in the offices of railway engineers, in connection with their bridges and viaducts. The present depths of estuaries and submerged plateaux are in the large-scale marine charts, while the raised beaches are known only to geologists, who, however, often pay too little attention to the shell fragments in the beach deposits. Even my friend Mr. Ussher, who knows well-nigh every rock exposure in South Devon, tells us of a consolidated bed of

comminuted shells lying on one of the low-level beach platforms, and passes on without further remark.[1] Comminuted shells are often quite enough for a conchologist, and might settle many important questions. In fact, one of the present difficulties is to account for shells with a southern range on Devonshire raised beaches of the same levels as the Irish glacial beach-platforms. But that is perhaps a comparative trifle compared to others.

By a curious coincidence my friend Mr. Lamplugh published his account of the Bridlington pre-Glacial beach in a British Association Report in 1888, and I published my own raised beach work in the Trans. Dev. Assoc. in the same year. Now Mr. Lamplugh's beach, so far as is known, contains only a few ordinary present-day shells and the mammalian cave fauna, with the addition of hippopotamus. These deposits rest on a chalk beach platform, and are covered with glacial deposits, indicating great cold. Thus the beach platform and the beach itself need not represent so cold a climate as that which followed. But in the Irish beaches described by Messrs. Wright & Muff, almost exactly on the level of Mr. Lamplugh's beach, we have, much further south, the rock platform itself ice-scored, affording no accommodation for hippopotami. If both these beaches are 'pre-some-glacial' (as has been neatly said by a great geologist), have we to exalt these superficial deposits to the 8,000 feet altitude of ice and snow and of aerial erosion of the most virulent type? Then when these beaches have descended again to the water-level in good preservation must we give them a further dip? These acrobatic oscillations, which geologists summon to their aid as lightly as they would call a hansom cab, absolutely confound the beach-student.

If we transfer the Bridlington beach mammalian fauna to Kent's Cavern, substituting beaver for hippopotamus, we find their horizon to be the cave earth and upper stalagmite, during the earlier part of which period England must have been continental to admit of the advent of the animals. As we find remains of the cave mammalia on beach platforms both at Bridlington and the Gower Peninsula, the question arises whether the beach platforms were cut before England was continental and before the arrival of the mammalia, or after the continental stage, and when the land and sea had returned to their former levels. In the former case the platforms and beaches would not be of the same age, whereas in the latter case they might be. The immense difference in character between the old crystalline and the new granular stalagmites in Kent's Cavern is best explained by difference of climate. Under glacial conditions the formation of stalagmite would be continuous even if intermittent[2]; though this may seem an Hibernianism. Under present conditions there would be alternate deposition and solution. Water charged with lime and carbonic acid entering the cave in summer would dissolve carbonate of lime, but in the winter would deposit it. The crystalline stalagmite indicates conditions dissimilar from the

[1] Memoirs Geol. Surv., No. 356, p. 68.

[2] E.g. the second-hand of a watch.

present, and may well also indicate glacial conditions. It is extremely difficult to adjust the evidence of beaches, raised beaches, caves, and other geological phenomena; but were it not for such uncertainties geology would not possess the interest which it certainly has.

There are two periods of indefinite duration concerning which the Kent's Cavern deposits are silent, viz., the time between the crystalline stalagmite and the advent of the hyæna, and the time between the close of the granular stalagmite (synchronous with the disappearance of hyæna) and Neolithic and modern times. There is also a good deal of inferential evidence from the molluscs found in the cavern, including *Venus chione* and full-sized *Pecten maximus*, but induction from those premises would most certainly be scouted as merely speculative. More 's the pity! One thing is pretty sure, and that is that neither the Torbay raised beaches nor Kent's Cavern have been submerged since the era of the cave earth and of the cave mammalia. At any rate, the evidence seems to preclude that possibility.

I have no desire to press my opinions on anyone, nor to contest the opinions of anyone, but I have tried to keep these geological physical problems alive in the hope that someone, some day, will work them out. They are certainly worth the attempt.

For more than thirty years I have seen from my house what is perhaps the most intricate assemblage of beaches, raised beaches, platforms, shelves, shore ledges, foreshores, submerged forests, and drowned valleys that can be seen from any one spot in England. I cannot forget them, for I cannot look out of the window without having them actually or mentally before me. In the middle distance is the limestone plateau of Daddy Hole Plain, a true plane, not a peneplain; beyond the bay with its submerged plain of many square miles, as flat as a billiard table, is the platform or terrace of Berry Head, overhanging the shore ledge and raised beach near the old Naval Hospital. This terrace can be traced by the eye as far as Galmpton Common, where it serves for golf-links; and beyond it is seen the drowned and partly silted-up valley of the Dart. Following the line of the coast we cross the filled-up valley at Goodrington, and passing the level and truncated headlands of Roundham Head, Livermead Head, and Corbons Head, we leave the submerged forest at Torre Abbey sands and the terrace of the Waldon Hill, to reach the filled-up submerged valley of Fleet Street, Torquay. With the mind's eye we can see, through the intervening hills, the raised beaches at Hope's Nose and the Thatcher Rock, and the higher platform of the Babbicombe Downs, also useful as golf-links. By the same means we can visualize the absolutely level 'continental shelf' of the bottom of Torbay, running out at right angles to, and falling rapidly into, the gentle seaward slope of the Great West Bay. We also mentally take note of Kent's Cavern and of the several caverns at Brixham. Further inland we have the higher lands in which aerial erosion has obscured any traces there may be of marine erosion.

So far as my experience goes, there is no Englishman who takes a lively interest in all these phenomena, but perhaps some day Dr. Nansen will look at them in the light of his profound acquaintance with the more fully developed marine sculpturing of Scandinavia.

The Torquay marine platforms and shelves, drowned valleys, and submerged forests are duplicated remarkably on the coast of Galloway, and curiously enough the headland corresponding to Berry Head is called the Burrow Head!

If we examine an ordinary map of the South of England we shall note that the Lizard Head, Prawle Point, and Portland Bill are nearly in line, the Prawle Point projecting, with deep bays both east and west of it; both the Lizard and the Prawle having stoutly, and apparently almost perfectly, resisted the attacks of the waves. We see in the rocky foreshore at the Prawle, nearly a quarter of a mile from high-water mark to the furthest reef uncovered at low tide, how hard the fight has been. This four hundred yards tidal platform cut in the hard metamorphic rocks of the Prawle district is a very significant phenomenon. If we follow the line of coast eastward we find the great resistance collapses when the metamorphic rocks are passed, but minor resistances will be noticed at Froward Point, near Dartmouth, and in the massive limestones of Berry Head. Then resistance is for a time entirely overcome, and the sea forces its way due north across the present entrance of Torbay to Hope's Nose and beyond, where, however, we need not follow its victorious career. The south-westerly gales having failed to overcome the massive Berry Head limestones, down Channel easterly gales attacked the new line of coast, at right angles to the original course of marine erosion, and cut out Torbay. Now it is clear that the northern Torbay raised beaches could not exist till the coastline had reached their positions, nor could the southern Torbay raised beaches exist till after the east and west erosion of Torbay had made much progress. Thus the erosion that took place between the first attacks on the Prawle coast and the formation of the Torbay beaches is a measure of the time that elapsed between those two events; and the subsequent erosion of Torbay westward and of the great west bay northward is a measure of the time that has elapsed since the formation of the Torbay raised beach platforms or 'shore ledges.' The latter amount of time elapsed carries us back to a period when *Trophon truncatus* was abundant in the English Channel, whereas now it is absent therefrom. But how much further back does the earlier period of erosion take us? That is the question. But that remote period witnessed the commencement of marine erosion on the Prawle coastline.

Geologists make free with local elevations and subsidences, but the fact seems clear that at Bridlington, in the Prawle district, and on the south-east coast of Ireland, sea and land at these distant localities are now within a few feet of the levels they occupied in the remote Pleistocene past.

I sometimes wonder whether the time is irrevocably passed, and the opportunity irretrievably lost, for these problems to be solved. Not only has the resistance to these problems on the part of scientific authorities been most marked in my own case, but the whole aims and objects of the British Association for the Advancement of Science by Research have been altered. The Association is now openly advocating the principle of teaching by professional men. A leading scientific weekly rejoiced that the Association was so much more in the hands of professionals at Cambridge in 1904 than it was at Cambridge in 1862; and I cannot but acknowledge that subjects which won for me the General Committee in 1879 would not now find me a place on a Sectional Committee. I cannot pretend to say that I do not regret it. I regret it very much, not for my own sake, but for the sake of what seems to me a most profitable object of research, a subject which in the hands of such men as Lyell, De la Beche, Godwin-Austen, and Daniel Pidgeon would have borne much fruit: for in science, as in agriculture, the harvest must be gathered when the crops are ripe; missed opportunities often, nay generally, do not recur.

VIII.—On the Relation of the Sands and Clays of Dorset and Hants to those of Bovey Tracey.

By the Rev. O. Fisher, M.A., F.G.S.

I HAVE read with interest Mr. Lowe's article[1] on Devonshire geology, in which he discusses the question whether the Bovey beds are Miocene or Eocene, and what may be their relation to the Hampshire and Dorsetshire Lower Bagshots.

In former years I have had some acquaintance with the Hants and Dorset beds, and I have seen the Bovey deposit and was struck with their similarity. I am much impressed with the weight of Mr. Lowe's objection that the enormous amount of detritus represented by the sands and clays extending from Bournemouth—or we may even say from Whitecliff Bay, I.W.—to Bovey can hardly have been derived from so small an area as Dartmoor.

My own impression is that there once existed an area of plutonic rocks in the Channel which supplied the clays and sands of the Hants and Dorset Bagshots. We know not to how great a distance the southern edge of those beds may have originally extended. As far as they are exposed, from Blackdown west of Dorchester to Whitecliff Bay, they are truncated by a great upcast fault. They may, for aught we know, have once extended to the foot of a granitic range now no more. The surface contour of the area south of their basset edge must have been profoundly altered by that great disturbance, and there is no impossibility in there having been a lake or lagoon in which Bagshots were deposited where now Cretaceous and Jurassic strata have been protruded. Such an explanation of the phenomena would bring the Hants and Dorset Bagshots into the same category with the Bovey deposit, both being

[1] See Geol. Mag., June, 1905, p. 269.

the washings of granite uplands, standing respectively in near proximity to the areas of deposition.

I believe the idea of a granitic source in what is now the Channel first occurred to me from observing many crystals of pink felspar, very little rolled or broken, lying on the surface of the heath a few miles east of Dorchester. This was more than fifty years ago; but I think the locality will be found near the spot marked "Dick of the Banks" on the ordnance map. Unless I am mistaken the felspar of Dartmoor is white or grey, so that these crystals being pink points to a different source of origin. Boulders of plutonic rocks occur on the shore at Selsea, showing that such rocks must have existed in the Channel area.

As to the question whether such a subaerial source of granitic detritus as I have suggested can have existed in the Channel area during Eocene times, we find that Godwin-Austen considered the Channel to be a valley of depression, and thought that it might have been dry land until Pleistocene times; while his contour chart of the sea bottom shows a remarkable shoal, rising within seven fathoms of the surface, nearly opposite the eastern end of the Isle of Wight.[1] May not this indicate the position of the remnant of a former boss of granite?

REVIEWS.

I.—Recherches Géologiques et Pétrographiques sur l'Oural du Nord. 2nd memoir. By Professor L. Duparc and Dr. F. Pearce. Mem. Soc. de Phys. et d'Hist. Nat. de Genève, vol. xxxiv, p. 383 (1905). pp. 219, 1 map, 5 plates, 30 figures, and 29 cuts in text.

THE first part of this memoir, dealing with the physiography of the Northern Urals and the petrography of Mount Koswinsky, appeared in 1902, in an earlier fascicule. Like it, that before us exhibits the most conscientious elaboration of every detail, especially petrographic—possibly sometimes carrying this almost to an excess—and describes the Tilaï-Kanjakowsky-Cérébriansy chain, with the petrography of its rocks and their modes of occurrence from west to east, from the watershed between the two continents up to the Devonian of Koswa. It contains illustrations of scenery which confirm the impression, produced by the former part, that for a comparatively mountainous region it is bare and rather monotonous. Its rocks of deep-seated origin are: (*a*) pyroxenites with olivine and magnetite; (*b*) gabbros of various types and structures, often containing olivine; (*c*) gabbros with uralite and diorites: the hornblende abundant, the olivine rare; (*d*) norites with hypersthene and diallagic diopside; (*e*) dunites with partially serpentinized olivine and chromic iron. The dyke or vein rocks are: (*a*) dunites, often more completely serpentinized; (*b*) berbachites (granular aggregates of diallage, magnetite and Labrador felspar); (*c*) hornblendic

[1] "On the Valley of the English Channel": Q.J.G.S., vol. vi.

pegmatites; (*d*) garewaïtes (granular aggregates of olivine, basic plagioclase, and chrome-iron, with porphyritic crystals of pyroxene). Rocks composed largely of the last mineral, which frequently belongs to the diopside division (or occasionally hornblende), seem to be very characteristic of the northern part of the Ural chain. The former memoir distinguished one of these, composed of lamellar pyroxene, with olivine, magnetite, and some hornblende, by the name koswite, and the present one describes and figures other examples, together with tilaïte, a granular rock, consisting of pyroxene (chiefly), with magnetite or spinel, a little plagioclase felspar, and occasional representatives of the following: olivine, hypersthene, hornblende, and biotite. The rock evidently is intermediate between the true pyroxenites and the gabbros, to one or other of which it may incline. Chemical analysis shows it to be richer in alumina, lime, and silica, but poorer in magnesia than the picrites, while it is richer in lime and silica, and poorer in alumina, lime, and magnesia than the troktolites. Thus the coinage of a new name is justifiable. The rocks of the Northern Urals evidently contain some very interesting types, and Professors Duparc and Pearce deserve the gratitude of students for their exhaustive memoirs. T. G. B.

II.—Le Minerai de Fer de Troïtsk. By Professor L. Duparc and Professor L. Mrazec. pp. 115, 6 plates, 2 geological maps, and 13 figures in text. (St. Petersburg, 1904.)

RATHER thick banks of magnetite are worked, at more than one place, near the village of Troïtsk, in the Urals, at the junction of a granite-porphyry and a black schistose rock, referred to the Lower Devonian. M. Krasnopolsky gave a short description of the district in 1889. He and Professor Mrazec now publish a more minute account, accompanied by full petrographical and mineral details, proposing an hypothesis to explain the presence of the ore that is found to occur as enclosures in the granite-porphyry as well as in layers which are separated by bands of 'cornéenne' variable in thickness. Of the latter there is more than one type, of which they give petrographical studies, assigning its metamorphism to the granitic rock, which also is fully noticed. The Devonian strata are shown to be considerably more recent than the 'cornéenne.' As the authors agree with Professors Michel-Levy, Barrois, and La Croix in attributing important chemical changes to the action of intrusive rocks like granites (admitting, however, that there are two sides to the shield), they offer the following explanation of the presence of the magnetite. This was introduced into the 'cornéennes' by the magma which furnished the granite-porphyry, but its position is due to the action on the sedimentaries, and comes from a fixation in them of the iron, derived from that magma. They believe the latter to have mounted slowly, and to have formed, under orogenetic pressures, a kind of laccolite which absorbed some of the covering rocks and developed the magnetite in adjacent masses, thus forming the zones of ore near the contact. Then increased pressure ruptured the covering rocks, ejecting a quantity of magma, and enveloping

fragments of them already mineralized, thus forming the ore deposits surrounded by the granite-porphyry. The crystallization of that rock then became complete, after which the mass was elevated and exposed to denudation during the formation of the Devonian rocks, and at later periods was affected, as described, by other earth movements. The explanation is not without its difficulties, which cannot be stated in a few words, but that does not affect the value of the treatise as a conscientious piece of work, and a history of a very remarkable mineral deposit. T. G. B.

III.—Dr. O. Abel. Fossil Sirenia of Austria.

Die Sirenen der mediterranen Tertiarbildungen Österreichs. —Abhandlungen der k.k. Geologischen Reichsanstalt. Bd. xix, Heft 2, pp. 1–223, with 7 plates and 26 text-figures. (Vienna, 1904.)

THIS is perhaps the most valuable memoir on the Sirenia that has appeared for some years, for although from the title it might be supposed to deal only with the fossil Sirenia from the Austrian tertiaries, this is far from being the case. The author first discusses in considerable detail the limits of the genera *Halitherium*, *Metaxytherium*, and *Felsinotherium*, and describes the peculiarities of their skeletons and teeth. He points out that these genera are a succession of forms passing more or less one into the other. *Halitherium* ranges from Upper Eocene to Lower Miocene, *Metaxytherium* from Lower Miocene to Pliocene, while *Felsinotherium* is confined to the Pliocene. In the second part of the memoir the writer describes in detail remains of *Halitherium Christoli*, *Metaxytherium Krahuletzi*, and *M. Petersi* from the Austrian Miocene.

The third part of the memoir is perhaps the most valuable and interesting. It consists of a discussion of the modifications of the Sirenian skeleton from the earliest known forms from the Middle Eocene of Egypt to the types still existing. Each of the important parts of the skeleton is considered in turn, and it is shown that in each there has been a gradual modification in a definite direction. Thus the earliest types possess a full set of incisors and canines which disappear in the later forms, their place being taken by the horny covering of the front of the jaws, though in some cases a pair of tusks, probably equivalent to the second incisors, may persist. In the molars there is a gradual increase of complexity resulting from the addition of secondary tubercles to a primitively bilophodont tooth, each transverse crest of which consists of a pair of cusps. Still more important are the changes that are shown to take place in the pelvis. For the first time the author figures and describes a Sirenian pelvis in which all the elements are complete, the obturator foramen being entirely enclosed by the ischium and pubis as in ordinary land mammals. This primitive form of pelvis is found in *Eotherium* from the Mokattam Limestones (M. Eocene) of Cairo, a Sirenian first described by Owen from the cast of a cranial cavity, and its discovery is a great step towards bridging the gulf between the Sirenia and their terrestrial ancestors.

Eotherium clearly must have possessed a functional femur which was probably not employed exclusively in swimming, but shows that this undoubted Sirenian may have been to some extent amphibious. Moreover, this pelvis is extremely similar to that of *Mæritherium*, a nearly contemporary Proboscidean, a circumstance that constitutes another piece of evidence in favour of the view that the Sirenia and Proboscidea have a common origin.

Finally, the fourth part of the memoir is devoted to the consideration of the genus *Metaxytherium*, and the result that the author arrives at is, that, while *Manatus* is in many respects different from the other members of the group, *Eotherium*, *Eosiren*, *Halitherium*, *Metaxytherium*, *Felsinotherium*, *Halicore*, and *Rhytina* form a closely related series.

The memoir is illustrated by excellent photographic plates illustrating some of the more important series of modifications in different elements of the skeleton. C. W. A.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—May 10th, 1905.—R. S. Herries, M.A., Vice-President, in the Chair.

The Chairman announced that the Council had resolved to award the Proceeds of the Daniel Pidgeon Fund for 1905 to Thomas Vipond Barker, B.A. Oxon., who proposes to investigate the deposition of crystals of minerals and other substances in regular position on each other, with special reference to such groups as those of calcite, barytes, aragonite, etc.

The following communications were read :—

1. "The Geology of Dunedin (New Zealand)." By Patrick Marshall, M.A., D.Sc., F.G.S.

The paper opens with an account of the physiography of Otago Peninsula and the adjacent mainland, in which the origin of the land-forms is briefly discussed. The author then passes on to a detailed account of the petrography of the district. The age of the oldest rocks seen, mica-schists, is not definitely known; they have been referred to the Archæan and to the Silurian systems. They are followed by about 1,000 feet of Tertiary sandstones and limestones, which contain sufficient fossils to class them with the Oamaru system of Oligocene age (Hutton) and with the Cretaceo-Tertiary of the Geological Survey. Fine, plant-bearing shales succeed unconformably; and upon these, again, rests a pumice or light scoria bed. These rocks are in their turn covered by the igneous rocks next described.

The rocks described include an ill-exposed, gold-bearing syenite; a diorite, with an uneven and weathered surface, underneath the lavas; rhomb-porphyry containing anorthoclase, and partly intrusive, partly interbedded; tinguaite, in the form of dykes; hypabyssal trachydolerite, containing nepheline and ægirine, and sometimes sodalite and analcite; a teschenite dyke; and trachyte, notably

lacking in ferromagnesian minerals, occurring in dykes and lava-flows. A large number of trachytoid phonolites occur in the form of interbedded sheets; they are divided by the author into five principal varieties, one of which bears leucite. Nephelinitoid phonolite is rare. A considerable number of rocks are classified as trachydolerites apparently occurring as lavas. The andesites are characterised by hornblende and augite, with little or no olivine; basanite is restricted in its occurrence. Dolerites of two principal types occur in dykes, one type being the commonest of all the rocks in the area. There are many lava-flows and some dykes of basalt; and one melilite basalt is found in the extreme north of the district. A note is appended on the economic application of these rocks.

A considerable series of chemical analyses follows, showing that the silica percentage varies from 66 in the Portobello trachyte to 44·84 in one of the dolerites. The petrographical differences are coincident with the chemical differences, and the rocks are generally similar to rocks of the same classes in other parts of the world, and more particularly to those of East Africa. A classification is attempted, according to the methods proposed by Pirsson, Washington, and Iddings; but the author concludes that, in his case, this classification, while grouping the rocks according to their chemical relationship, is unsatisfactory from a geological standpoint. The chemical composition of the rocks is further represented in diagrams constructed according to the method employed by Hobbs. These diagrams show clearly the chemical differences between the alkaline and the basic series, and the extent to which this hiatus is bridged over by the trachydolerite and basanite. The series, however, does not show a gradation similar to that described by Professor Brögger in the Christiania rocks.

In the concluding section of the paper the relative ages of the volcanic rocks are worked out, so far as possible. The order does not appear to be explicable on any theory of magmatic differentiation, but it is suggested that it may be due to the mixing of magmas before and during eruption.

2. "The Carboniferous Limestone of the Weston-super-Mare District." By Thomas Franklin Sibly, B.Sc. (Communicated by Dr. A. Vaughan, B.A., F.G.S.)

The Carboniferous Limestone of the Weston Worle Ridge includes the greater part of the *Syringothyris* zone (C), extending from the '*laminosa* dolomites' upwards, and a large part of the *Seminula* zone (S). While the dip of the rocks of the ridge is towards the south, a reversed fault throws the *Syringothyris* Beds on the south against the *Seminula* Beds to the north, and the latter rocks are overfolded on the north side of the fault. To the south of the fault there is a sequence from C_1 to S_2; to the north, S only is represented. The lower part of C_1, consisting of the '*laminosa* dolomites' and the '*Caninia* Oolite,' resembles the equivalent part of the Clevedon sequence, and indicates shallow-water conditions; the upper part of C, consisting of a thick mass of fossiliferous limestone, closely resembles the corresponding part of the Burrington

section, and indicates the predominance of a Mendip facies. Much dolomite occurs in the lower part of S, indicating shallow-water conditions during part of *Seminula* time. There is a distinct development of the *semireticulatus* subzone (S_1), which exhibits a faunal overlap between C and S; and the base of S_2 is remarkable for its rich and varied fauna.

The Woodspring Ridge shows a sequence from the Upper *Zaphrentis* zone (Z_2) to the top of C_1, the whole sequence being exactly similar to that of Clevedon. In this ridge the contemporaneous igneous rocks occur in horizon γ. In the Weston Worle Ridge they are put above the '*Caninia* Oolite,' that is, about 450 feet below the top of C. It is, therefore, evident that there were two periods of volcanic activity, one of which occurred at the close of *Zaphrentis* time and the other early in *Syringothyris* time. Notes are given on the faunal sequence.

II.—May 24th, 1905.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "On the Igneous Rocks occurring between St. David's Head and Strumble Head (Pembrokeshire)." By James Vincent Elsden, B.Sc., F.G.S.

The author finds that the contemporaneous lavas of the Llanrian area agree generally in character with the eruptive rocks of apparently Ordovician age in the Strumble Head and Prescelly districts. These are all of an essentially acid type. The intrusive rocks of the area are of later date, and belong to three distinct types:—(1) The gabbros and diabases of the Strumble Head area; (2) the norites and associated rocks of St. David's Head and the surrounding district; and (3) the lime-bostonites and porphyrites of the Abercastle Mathry district. Detailed petrographical descriptions of the different types are given, accompanied in many cases by analyses and comparisons with corresponding or related rocks of other areas. The lime-bostonites, which have affinities with those of Mænaa described by Brögger, but are much more basic than the Wicklow keratophyres, are apparently the oldest of the intrusive rocks, and seem to belong to the petrographical province of South-Eastern Ireland. The gabbros and norites were intruded approximately during the same interval; at a later period the norites, enstatite-diorites, and the rest of the rocks associated with them spread north-eastward from St. David's Head, and penetrated the area of the Strumble Head intrusions. Similarly, the gabbros and diabases spread to a more limited extent south-westward into the norite area. In the overlapping area the gabbro and norite provinces are separated by an ill-defined zone, in which some mixture of the two magmas took place. The latest phase of igneous activity was the formation of the Pen-Caer basalt-laccolite, with apophyses penetrating the Garn-Fawr to Y-Garn intrusions. It is not necessary to assume that each of the several intrusions was confined to any single stage of vulcanicity. The laccolites and bosses were probably the result of injections extending over a prolonged interval from co-existing magma basins, or from a single

differentiated magma. There are clear evidences of some further differentiation *in sitû*, but the full extent to which this took place offers a large field for future investigation.

2. "The Rhætic and Contiguous Deposits of Glamorganshire." By Linsdall Richardson, F.G.S.

The principal sections in the county are described in detail, the chief being those at Lavernock (near Cardiff), Barry, Tregyff (near Cowbridge), Quarella (Bridgend), and Stormy Down. The Sully Beds, a name given to the fossiliferous portion of the 'Grey Marls' of Etheridge, are determined to belong to the Rhætic Series, on account of the fossils that they contain. They are quite distinct from the 'Tea-Green Marls,' in which fossils have not been observed. Earth-pressures affected the rocks during the formation of the Sully Beds; the *Avicula contorta* black shales rest upon them with perfect parallelism, but even then non-sequentially. Owing to an upheaval of the Lavernock district early in the age in which the Upper Rhætic Stage was deposited, only a portion of the lowest bed of that stage is found, and this deposit was subjected to subaërial denudation during the accumulation of the remaining Upper Rhætic beds elsewhere. But subsidence again in the same district allowed of the deposition of the White Lias, and as a result this latter rests non-sequentially upon a portion of the lowest part of the Upper Rhætic deposit. The White Lias, at certain localities in Glamorganshire, contains in abundance *Plicatula intusstriata*, *Pl. hettangiensis*, and *Lima valoniensis*. The deposit intervening between the Sun Bed and the Upper Rhætic near Bath (Newbridge Hill) is over 11 feet thick; at Lavernock the equivalent deposit measures but 2 feet $2\frac{1}{4}$ inches. At Lavernock, however, above the probable equivalent of the Sun Bed, are marls 6 feet 4 inches thick, which are provisionally grouped with the White Lias. Above come the Paper Shales, succeeded by the *Ostrea* Beds. The Upper Rhætic of North-West Gloucestershire and Worcestershire is not the equivalent of the White Lias of this or of the Bath district. The White Lias occurs above the Cotham Marble (the topmost bed of the Upper Rhætic) and below the Paper Shales (which occur immediately below the *Ostrea* Beds). Palæontological notes on certain of the fossils are appended, including *Ostrea Bristovi*, Etheridge MS., which is very abundant in the Sully Beds.

3. "On the Occurrence of Rhætic Rocks at Berrow Hill, near Tewkesbury (Gloucestershire)." By Linsdall Richardson, F.G.S.

About 2 miles south-east from Chase End Hill (Malvern Hills) there is a small outlier of Lower Liassic and Rhætic beds, in a basin-shaped area, supported and surrounded by Keuper Sandstone. A detailed section is given, mainly obtained by excavation, and this is compared with the nearest locality where the whole of the Rhætic may be studied, namely, at Wainlode Cliff. At Berrow Hill rock at the base of the Lower Rhætic, at least $3\frac{1}{4}$ feet thick, is missing; consequently Bed 13 rests directly, and with perfect parallelism (so far as can be seen), but non-sequentially, upon the 'Tea-Green Marls.'

III.—June 7th, 1905.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "The Microscopic Structure of Minerals forming Serpentine, and their Relation to its History." By Professor T. G. Bonney, Sc.D., LL.D., F.R.S., V.P.G.S., and Miss C. A. Raisin, D.Sc.

The authors, after a brief reference to investigations of serpentine during the last thirty years, which still leaves some points unsettled, describe the formation of that mineral from sundry ferromagnesian silicates. Having given a summary of the changes in olivine, they describe more fully the alteration of separate grains in the so-called 'kimberlite' of South Africa. Then, after referring to the serpentinization of amphibole, as illustrated in the well-known Rauenthal rock, they enter more fully into the changes, first, of the orthorhombic pyroxenes; then of the monoclinic. To illustrate the latter, they describe the conversion of malacolite into serpentine in the well-known '*Eozoon*' rock of Côte St. Pierre, and of some augite-bearing serpentines in the Vosges. An investigation follows of the form of serpentine called 'antigorite,' described by Dr. Hussak (in 1883) from Sprechenstein on the Brenner Pass, and asserted to exhibit a 'netting-like' (*gestrickte*) structure, which is a record of the nearly rectangular cleavage of the original augite. They show, by study of specimens collected in the Sprechenstein district by Miss Raisin, that no such connection exists, and that the netting-like structure has often only a subjective existence.

The mica-like mineral called antigorite is shown to be abundant in the Pennine Alps about the head of the Vispthal, and to lead to the same conclusion, suggesting, no less than the Sprechenstein specimens, a relation between that mineral and pressure. After a brief notice of the chemical changes in the conversion of the various anhydrous silicates into serpentine, the authors embody their investigations in the following conclusions:—

(1) That both a tint and pleochroism are accidental rather than essential characteristics of antigorite.

(2) Neither are low polarization-tints characteristic, unless two mica-like minerals exist, otherwise indistinguishable.

(3) That it is doubtful whether any hard-and-fast line can be drawn between antigorite and the more fibrous forms in ordinary serpentine rocks.

(4) That the most typical antigorite appears when the rock has been considerably affected by pressure, but it becomes less so when the latter has been very great.

(5) That so far from the nearly rectangular cleavage of augite originating the 'gestrickte struktur,' it is worse preserved than any other original one in the process of serpentinization. Typical antigorite, however, apparently is rather more readily produced from augite than from the other ferromagnesian silicates, but is more directly a consequence of pressure than of chemical composition.

2. "The Tarns of the Canton Ticino." By Prof. E. J. Garwood, M.A., Sec. G.S.

The lakes dealt with comprise the larger Alpine tarns which occur

in the Canton Ticino. Most of these drain into the Ticino basin; one or two, however, flow into the Reuss or the Rhine.

Val Piora Lakes.—These are chiefly rock-basins which lie in all cases along the junction of two dissimilar rock-masses. Detailed soundings prove that the axes of greatest depth of the lakes coincide with these lines of junction: one side being a dip-slope, the other an escarpment. It is shown that in the case of three of the larger lakes soluble calcareous beds have been brought by thrusts against crystalline rocks.

The origin of the lakes cannot be attributed to ice-excavation, as the ice must not only have invaded the district from outside, but must also have come from several different directions at once. Other difficulties in the way of accepting this mode of origin are also pointed out.

They appear to be due to structural peculiarities of the district, aided by solution. Analyses of the rauchwacké are given, and its characters are described.

The lakes appear to be connected with a reversal of the drainage of the Piora Valley, consequent on the over-deepening of the Val Levantina in Interglacial times and the elevation of the upper end of the district as the ice-cap melted away.

Two of the other lakes of this group lie on or near the watershed: their origin is difficult to account for, except by differential weathering along the lines of junction.

Lago Tremorgio Group.—These tarns are all situated either on the calc-mica-schists or on outcrops of crystalline limestone and dolomite. Lago Tremorgio itself is almost certainly due to solution. A typical analysis of the schists gives 75 per cent. of calcium-carbonate. This occurs chiefly in the form of eyes of granular calcite which crumble between the fingers, and is found to be dissolved out in the submerged rock, while sharp reefs run out under water.

Soundings show a depth of 150 feet near the exit, which is a narrow water-cut gorge. The lake is otherwise entirely surrounded by a steep wall of rock, the lowest point in which is 718 feet above the lake. It is impossible to suppose that ice has scooped out this basin. The fact that springs issue from the side of the valley below the lake all the year round, and that the level of the lake falls 20 feet below its exit in Winter, points strongly to solvent action.

Of the remaining lakes scattered along the southern side of the Ticino watershed, the Lago di Naret has a wedge of crystalline limestone running through the centre, while the Lago Sciundrau is situated on the junction of dolomite and gneiss, and the Laghetti to the east of Lago di Naret lie along the junction of the calc-schist and the gneiss.

The St. Gothard Lakes.—The rock-basins here also occur along the line of junction of schists and gneiss. The Lago Lucendro is the most important, and soundings show an axis of greatest depth running along this junction. Solution does not appear to have played much part in its formation. Possibly the glacier which descended from Piz Lucendro has removed fragments along the